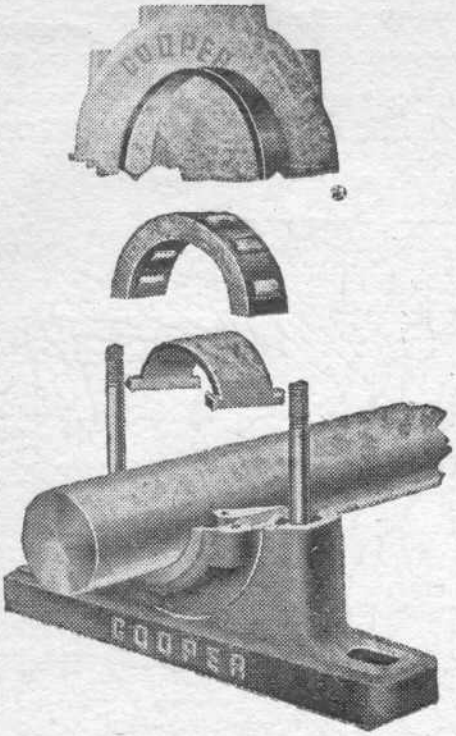
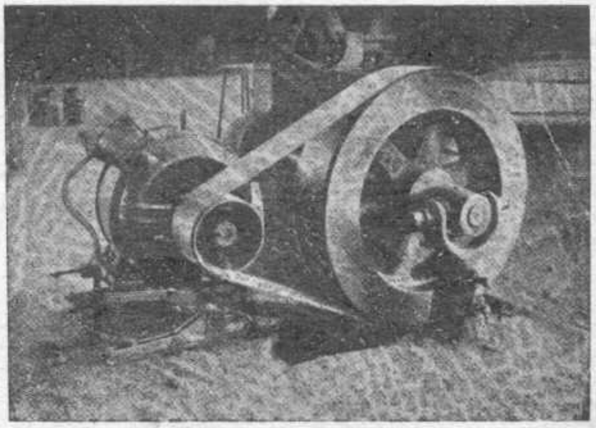
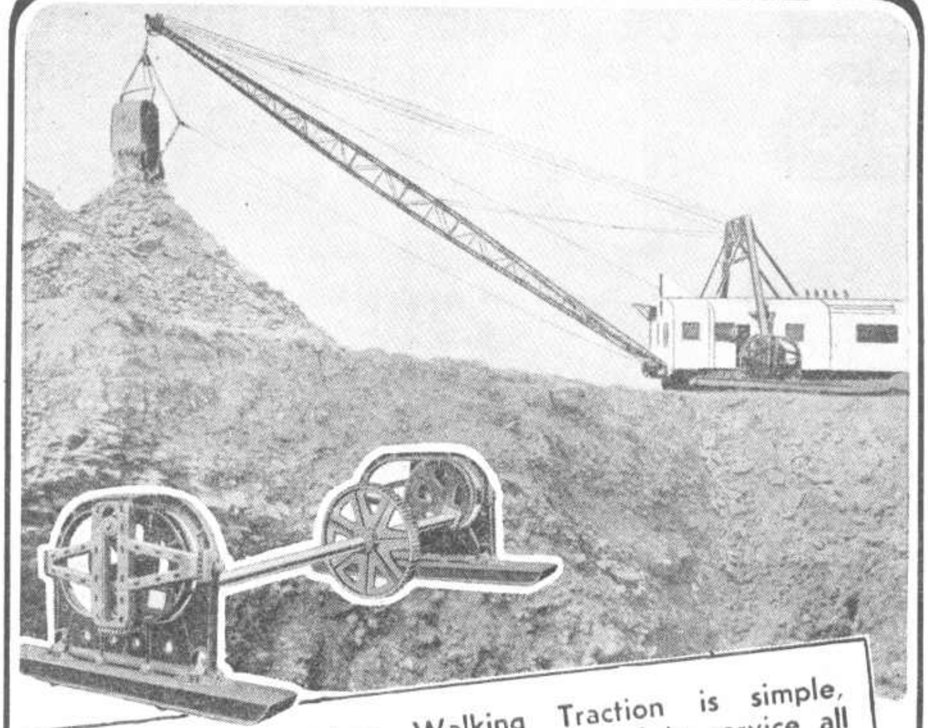
1945

ADELAIDE UNIVERSITY ENGINEERING SOCIETY MAGAZINE


COOPER
COOPER





CONTENTS

THE ADELAIDE UNIVERSITY ENGINEERING SOCIETY MAGAZINE

Artium ubertas et scientiae

Volume I, No. 1 November, 1945

ADVERTISING .... P. BROKENSHA

EXCHANGE .... P. G. B. CLARIDGE

PHOTOGRAPHY .... K. R. STEPHENS

Produced annually by the Adelaide University Engineering Society,
University of Adelaide, Adelaide, South Australia

PRICE: 2/6

Preface . . . . .

AS this is the first publication of a magazine by the Engineering Society, a note of explanation may be necessary. This magazine is edited and almost wholly written by undergraduates. The matter is, therefore, neither very technical nor advanced, but will, we hope, appeal to all students. It is for this reason that we have included more or less popular articles on Television, Jet Propulsion, etc. We also hope that the writing of articles for publication will help students to write clear and correct English. For this reason none of the articles have been drastically edited but have been left in their original form.

We would like to thank all those people who helped in the production of this magazine, especially Mr. K. Stevens for his photographic work and Mr. D. E. Martin for his drawings. We also wish to thank "Flight," London, for kind permission to use jet plane photographs.

This magazine is to be published annually, and with our increased knowledge and experience we are sure that next year's magazine will be far better.

—The Editors.

FOREWORD

By PROFESSOR R. C. ROBIN, M.E., Dean of Engineering Faculty, University of Adelaide.

WRITING a brief article of welcome to the new Journal gives me the opportunity of airing a theme dear to the late Professor Gartrell as well as to me. This theme is the need of a broader education for engineers. In elaborating this subject, an important difference between the curricula of engineering schools in British communities on the one hand and those of many similar institutions in the United States of America on the other, should be pointed out. My excuse for relating a difference in curricula in two separate regions to an undergraduate paper is that I hope the new Journal will do something to bridge the gap.

In brief, the ideal of many American Engineering Schools is that their graduates shall be given a liberal as well as a technical education. Inspection of the catalogues of such institutions shows that the engineering student is required to take courses in English literature, English writing, economics, history, and other subjects pertaining to the humanities in addition to science and engineering. The ideal is a fine one, and the reasons for selecting it as an ideal are valid. An engineer is a citizen as well as a professional man, and surely it is just as important that he be a good citizen as a good technical man, and there is no reason why he should not be both. Engineers in exercising their functions as applied scientists have been instrumental in causing fundamental changes in the social fabric and way of life of the communities in which they live. Such changes are bewildering not only by reason of their magnitude, but also because of the rapidity with which they occur. The leaders needed by the community should therefore be able to foresee the changes which will be brought about by this or that industrial advance. Engineers understand industrial advances better than members of any other profession, and therefore are equipped, in part at least, for leadership. To be fully equipped they must be able to detect the trend of modern life, and therefore need a broad social education. It is to supply the broader education that so many engineering schools in America have included in their curricula certain of the humanities. Unfortunately, there is evidence that the engineering undergraduate has not taken full advantage of the opportunities offered him. Often too often, it seems, he has viewed the non-technical subjects merely as another set of hurdles between him and the professional qualification he is seeking. An interesting variation has been instituted at one school (Purdue), where the engineering student may elect to take either a course wholly technical in its content, lasting for four years, or one covering the same scientific and technical ground, but with sufficient cultural subjects added to spread the course over five years. This arrangement has the advantage that presumably only those really interested would elect the longer course.

In British Universities on the other hand, the content of engineering courses has, with few exceptions, been limited to science and applied science. The authorities perhaps have concluded, as if with Candide, "Social responsibility, what is that but doing our technical job as well as we can? Let us cultivate our garden." It has been said in favour of the British system that true culture of the mind is not obtained by a wide and superficial reading, but in getting a real understanding of what is read, an understanding so thorough that the mind thus equipped can use the acquired knowledge to overcome the difficulties with which life confronts it. It was perhaps the failure on the part of most men of his time to acquire this real understanding that lead Hobbes to say contemptuously, "If I read as many books as most men I should be as dull witted as they."

Whatever may be the final results of the two systems, the object in either case is the same, namely, the training of an engineer who will be a leader in the community.

The reader, if he has come so far with me, may well ask what all this has to do with the new Journal. The connection, a little tenuous perhaps, is this. The new Journal can provide very valuable training in leadership for such undergraduates as care to make the effort. It will provide executive positions for an appreciable number of men. Positions indeed of some difficulty, since the holders will have to sell advertisements, to cajole unwilling students to take up their pens and write. Those cajoled into contributing will gain. Knowing that their efforts will be held up for all the world to see, they will lavish upon their effusion more real literary effort than would be the case if the efforts had been intended only for the eye of a lecturer. Some people may even learn to spell.

Lastly the Journal may (and I hope it will) provide a forum in which engineering students, young and old, will put on record their convictions on subjects varying from cabbages to kings. If I make make a suggestion, a very fitting subject for the correspondence column might well be the question, "Should engineers be required to study the humanities?"

I welcome the appearance of the new Journal as evidence of initiative in the A.U.E.S. and wish the venture every success. May it unearth much totally unsuspected literary talent, including perhaps even a poet or two.

HOW ATOMIC ENERGY IS SET FREE IN THE BOMB

By PROFESSOR KERR GRANT,
M.Sc., Professor of Physics,
University of Adelaide.

THE theory of atomic structure accepted to-day assumes a minute core or nucleus in every atom, in which the whole of the positive electric charge of the atom and practically the whole of its mass is concentrated, while in the neutral (non-ionised) atom negative electrons just sufficient in number to compensate the positive charge of the nucleus whirl around it like planets round the sun. Actually, this model of an atom is only a crude and simplified picture of the real thing, but there is truth enough in it to serve our present purpose.

Since electrons have one and all the same charge, it is clear that the total nuclear charge must be an integral number of this unit and, since the chemical character of an atom is fixed by the number of planetary electrons, this integer, the atomic number, which ranges from one for hydrogen to 92 for uranium, determines the chemical character, though not necessarily the atomic weight, of the atom.

It is clear that the nuclei of all atoms, other than those of hydrogen, must be composite and the earlier supposition was, naturally, that they were built up of positive protons and negative electrons, the number of protons giving, approximately at least, the atomic weight, and this number less the number of electrons, the nuclear charge or atomic number. Thus, the helium nucleus, of atomic number 2 and atomic weight 4, was supposed to consist of 4 protons and 2 electrons; that of uranium (238) of 238 protons and 146 electrons.

While this theory was satisfactory up to a point, there were certain objections to it of a rather abstruse character, and with the discovery of the existence of the sub-atomic particles termed neutrons it was abandoned in favour of the "proton-neutron" theory of nuclear structure which at present holds the field.

The neutron is a particle of mass very nearly equal to that of the proton, but carrying neither positive nor negative charge. The helium nucleus consists of 2 protons plus 2 neutrons, that of uranium of 92 protons plus 146 neutrons.

It is clear that the existence of isotopic species of the same atomic number is equally well explained on either of the above theories. For example, the heavy hydrogen atom, of atomic number 1 and atomic weight 2 could be either 2 protons plus 1 electron or 1 proton plus 1 neutron. Clearly, also, there might be hydrogen atoms of atomic weight 3, 4, 5, etc., and so for other kinds of atoms any number of isotopes. The number (although reaching as high as 10 for tin) is however limited by considerations of stability. Since proton repels proton (by electrostatic repulsion) it would seem unlikely that there could exist a stable nucleus composed of, say, 3 protons and only 1 neutron, on any plausible assumption as to the binding power of the neutron. That there must be such a binding force is clear, but its precise nature is somewhat obscure. It depends upon what is called an "exchange" process within the nucleus in which the proton may change to a neutron or vice versa by an exchange of either a positive or a negative electron from one to the other.

As the nuclei get more and more complex stability does, in fact, grow less and less, as is shown by the instability (radio-activity) of all atoms of atomic number exceeding that of bismuth (83). In the uranium nucleus the extreme limit to which it is possible to build up a nucleus composed of protons and neutrons seems to have been reached, for neither in the stars (from spectroscopic examination of their light) nor on the earth has any trace of a "transuranic" element been discovered.

It is plausible that in the beginning, "when the heavens and earth rose out of Chaos" (in Milton's words), or, rather, in the genesis of each individual star (as the modern astronomer would put it) the first atoms to appear (heaven only knows from what origin) were those of hydrogen only; in fact, the spectra of stars of the hottest type show only the hydrogen lines. Next comes helium and then the elements of steadily increasing atomic weight. It seems clear that a building-up process is here going on in which the heavier atoms are successively built up from lighter. Such a process can be shown to involve an enormous output of energy. If helium nuclei, for example, of atomic weight 4.004 are built up from 2 protons (2 x 1.008) plus 2 neutrons (2 x 1.009) there is clearly a loss of mass of (4.034—4.004) = .030, that is, of 30 milligrams for every four grams of hydrogen used up. By Einstein's equation connecting mass and energy ($E = C^2m$) this implies a liberation of energy amounting to $3 \times 10^{-2} \times 9 \times 10^{20} = 27 \times 10^{18}$ ergs, or, in round figures, about one hundred thousand kilowatt-hours, a colossal figure. This is the basis of the often-quoted statement that a pint of water could conceivably furnish enough power to drive the Queen Mary across the Atlantic and back. This energy of nuclear upbuilding is the only conceivable source of the enormous stream of radiant energy which our sun and all its fellow-stars continue to pour out age after age into space.

As in all changes where energy-transformations are involved this loss of energy implies a transition from a state of lower to one of higher stability. The helium nucleus, in particular, is one of quite extraordinary stability; so great indeed, that alone of all elements above hydrogen, helium atoms have successfully resisted all attempts at transmutation by bombardment. Similarly, the stability of any other kind of nucleus can be judged by the magnitude of its "mass-defect"—i.e., the difference between its mass and the sum of the masses of all the protons and all the neutrons which compose it.

This mass-defect and the correlated stability steadily decrease as we ascend the atomic scale.

As Rutherford was the first to show it is possible to transmute a nucleus of one kind of atom into a different nucleus by bombardment with high speed particles. In his first experiments these particles were alpha-rays, then Cockcroft and Walton succeeded with protons; but, after the existence of neutrons had been brought to light and means of generating them discovered, it was found (by Professor Fermi of Rome in 1934) that these—in virtue of their neutral character—were far superior to protons as agents for transmutation. By using them, Fermi and others have produced over 300 new isotopes of known atomic species, most of them radio-active.

Fermi, in his work, gave particular attention to uranium, hoping to be able, by transmuting its nuclei, to produce atoms of atomic number 93 or higher, that is, "trans-uranic" elements. He believed that he did in fact accomplish this, though placing these new elements in the atomic system proved difficult. These difficulties were not removed when others repeated his experiments.

The radio-active isotopes of all the elements below uranium behaved normally in disintegrating, i.e., they emitted either alpha-rays, or positive or negative electrons with a resulting change of atomic weight of a few units at most. Fermi, naturally enough, assumed this would be true for the results of uranium-transmutation also.

But Professor Otto Hahn, of the Kaiser Wilhelm Institute for Radioactive Research in Berlin, with his collaborators, Strassman and Lise Meitner, by a long series of painstaking and difficult chemical tests, finally proved that some at least of the products of the uranium-nucleus plus neutron reaction were atoms of such elements as barium, lanthanum, etc., the atomic weights of which were roughly only half that of uranium. In other words, the change that took place was indeed a true "splitting of the atom," or, rather, of its nucleus, to which the term "nuclear fission" has appropriately been given. An immediate deduction was that this nuclear fission must be associated with the liberation of a relatively enormous amount of energy.

Suppose, for example, that the products of the fission were Xenon (54, 129) and Strontium (38, 88). The sum of the atomic weights of these is 217, which is less than that of U (238) by 21 units per atom. Comparing with the energy-equivalent for .03 (in the case of helium) it is clear that a relatively colossal amount of energy must here be set free.

Experiments on the bursts of ionisation associated with each fission and also direct measurement of the heat evolved when uranium, in a suitable calorimeter, was bombarded with neutrons fully confirmed this figure [of the order of 3×10^{-4} erg per fission, or (multiplying by the Avogadro number, 6×10^{23}) 18×10^{19} ergs per gram molecule.]

Converted into more familiar units, this means that the energy of the nuclear fission of 1 lb. of uranium would be roughly the same as that produced by the burning of 1,000 tons of coal, or, to quote from an article by Flugge (one of Hahn's associates) in "Die Naturwissenschaften" for June, 1939, "if all the uranium atoms in one ton of $U_3 O_8$ were simultaneously to undergo nuclear fission the energy thus liberated would suffice to raise a weight of 1,000 million tons to a height of 17 miles." The question immediately arose: since uranium nuclei contain a large excess of neutrons over protons, is it not possible, or even probable, that when fission occurs, certain of these would be set free and then, entering other nuclei, cause fission of these. If so, a "chain-reaction" of enormous violence would result with explosive rapidity from an initial excitation of fission by neutrons from some external source.

This question might have waited many years for an answer had it not been that the military potentialities of such an explosive led to an intensive and successful effort to solve it—though at gigantic monetary cost—by the United States and Britain. The results of that success are now known to all.

Atomic energy, set free by nuclear fission, is an agency of destruction surpassing in that respect the power of T.N.T. or any other "high explosive," as much as T.N.T. surpasses the destructive power of a cannon-ball. It renders all other forms of military weapon futile by comparison. If the nations of men ever again indulge in the homicidal and devastating practices of war, victory will go not to that nation with the largest army, navy, and air force, but to that which can command the biggest supplies of atomic bombs.

Whether this same energy of nuclear fission can be utilised for the worthier ends of constructive achievement in industry and science is a question which yet remains to be answered. There was argument and some evidence, even before the war, that it was possible to so control the rate of disintegration, that the energy of fission was converted into a steady supply of heat which could then, of course, operate a heat-engine in the usual way. Uranium is, however, a comparatively rare metal, and worse than that, the pre-war conclusion was that it was only in the nuclei of atoms of the rarer isotope of atomic weight 235, which are in the proportion of 1 : 140 to those of the more abundant U238, that a self-perpetuating chain-reaction was likely to occur.

If this conclusion is sustained, then to take the place of the 1,500 million tons of coal mined yearly for industrial power, something like 75,000 tons of uranium metal would be required annually. The largest production in the past, from the mines of the Belgian Congo and of Canada, has probably been less than 1,000 tons per annum. It is obvious that such an enormous increase is not likely to be attained, nor for that matter even one-tenth of the total required, without the consequence of a rapid depletion of the available ore supplies, and such a rise in price of uranium as would make the cost of power derived from it greater than of that at present obtained from coal.

It is possible, of course, that in the work of developing the bomb, some new discovery as yet unrevealed may have opened the door to a method of utilising the nuclear fission of both isotopes; it is not impossible that some future discovery may find a way of splitting heavy atoms other than those of uranium and thorium—which similarly undergoes nuclear fission under neutron bombardment. Until one or both of these aims is achieved, it seems unlikely that any large-scale employment of uranium for the generation of industrial power will eventuate. Its application, other than for military purposes, seems likely to be confined to the furtherance of research in nuclear physics and perhaps for special ends, such as the propulsion of high-speed stratosphere planes, in which concentration in volume and reduction of weight of fuel are highly important from a commercial point of view.

ADDENDUM

Since writing the above, information has been received and made public to a limited circle in Australia concerning the nature of the bomb, which modifies the speculated views expressed in the above considerably.

According to a brief verbal communication to the writer from one who has access to this information the technique of making the bomb is somewhat as follows:

1. Uranium is heavily bombarded with a neutron beam, which, besides producing neuclear fission, also converts, by neuclear capture without fission, atoms of U238 into atoms of U239. Presumably the neutron beams are obtained from cyclatrons, using heavy hydrogen ions to bombard a heavy hydrogen compound (e.g., heavy water).
2. U239 disintegrates by beta ray emission to give a trans uranic element of next highest atomic number 93, which has been called Neptunium.
3. Neptunium disintegrates by beta-ray emission to give element 94. This element, "Plutonium," has a half life of over 50 years, and consequently accumulates as long as neutron bombardment continues.
4. Plutonium is separated from the Uranium by simple chemical methods. It forms the explosive material of the bomb, no doubt undergoing complete neuclear fission when this is initiated by neutrons from an "executer," the nature of which is not disclosed.

Thumbnail Sketches of A.U.E.S. and Magazine Committees

FARSONS, RALPH: Known as Perce. President of the A.U.E.S. and phenomenal chap. Union Committee member. Main recreations: An Editor of magazine, doing Refectory III, and sailing. Third Year Electrical.

CLARIDGE, BRIAN: Perce's shadow and secretary of A.U.E.S. A noted wit, he has literary aspirations, and writes humorous short stories for "On Dit." Prominent bass in Glee Club and plays Rugby. Third Year Civil; also on Union Committee.

NICHOLLS, LESLIE: Treasurer of the society and a man of few words. Plays Rugby and is a lone survivor of practically extinct miners; also in his third year.

TYLER, DONALD: Vice-president of the society. He is an ardent Glee Clubber, professes to like English verse, and is a Fourth Year Civil.

WHITTLE, JIM: Vociferous member of A.U.E.S. Committee. Has a prominent jaw and plays a rugged game of football. Second Year Mechanical.

TROTT, LYN: Committee A.U.E.S. Returned soldier and a dark horse. First year.

ROUNSEVELL, JAMES: Known as Pee Wee. Secretary of the Glee Club, inveterate pipe smoker, a man of many words and many parts. An Editor of magazine. Plays hockey and is Fourth Year Civil.

BROKENSHA, PETER: Known as the Champ. Treasurer and ardent champion of the Labour Club. Plays A grade baseball, edited this magazine, and is a Third Year Civil.

ANGAS, MISS M. E.: Known far and wide as Maggie. Editor of magazine, writes "On Dit's" gossip, and is a Third Year Aeronautical.

COWLEY, G. R.: Committee A.U.E.S. Veteran of present war. Is doing a resumed electrical course.

TELEVISION

By STEPHEN KANEFF

Although it has been long promised to us, we in Australia have yet to see any television and very little has been heard of it during the war years. This article deals with the basic principles and some of the latest developments in this field.

THE basic idea behind television is somewhat as follows: An image or scene is broken up systematically and transformed into series of electrical impulses, which vary with the degree of light and shade. These electrical impulses are transmitted by conventional radio apparatus, received, and reformed into light images.

The breaking up of images into electrical impulses can be done either mechanically or by purely electronic means. The need for close manufacturing tolerances, high operating speeds, together with problems of maintenance and mechanical noise, is prejudicing the chances of mechanical television. The tendency at present is to use electronic means for home purposes and mechanical systems for large installations. This article deals with purely electronic television. It must be noted that a mechanical system transmitter can be received on a purely electronic receiver and vice versa, providing that all conditions of frequency, etc., are the same.

The heart of electronic television is the cathode ray tube or some refinement of it. Most readers probably understand the action of a cathode ray tube well enough, but a few details would not be without benefit to those who do not (a matter of opinion, of course).

Figure 1 shows the arrangement of electrodes in a typical cathode ray tube with electrostatic deflection. The cathode ray tube measures the strength of a current or voltage and is particularly valuable when the strength is varying rapidly. In television, its measurement ability is secondary to its ability to produce light variations with very great rapidity.

The beam forming system consists of a cathode, which is a flat surface coated with barium oxide, heated by a wire behind it. Electrons from the cathode flow through an aperture, then to another electrode, also with an aperture in it. This electrode, insulated from the cathode, controls the number of electrons in the beam in accordance with the voltage applied between itself and the cathode, and is called the control grid. The electrons then flow to the first anode, which is at a potential of several hundred volts more positive than the cathode. The main function of the first anode is to focus the beam by counteracting the tendency of the electrons to diverge under the influence of the mutual forces of repulsion. The second anode, usually at a potential 1,000 volts or more above that of the cathode, focuses and accelerates the electrons so that they form a narrow beam of high energy when they reach the end of the tube. The screen at the end of the tube is usually a coating of zinc orthosilicate (giving green colour) or cadmium tungstate (blue).

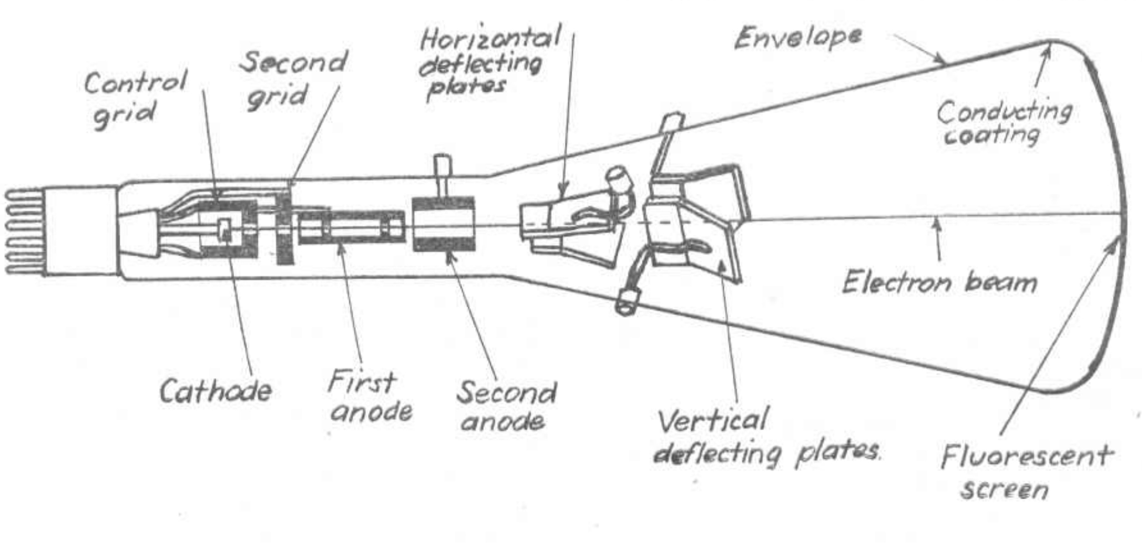


FIG. 1. TYPICAL CATHODE-RAY TUBE.

The inside of the tube is evacuated to a high vacuum.

The impact of the electrons on the screen produces light of a brilliance depending on the number of electrons and their energy. Some secondary electrons are produced by the impacts and these are removed by the conducting coating of graphite, connected electrically to the second anode. There are two sets of deflecting plates are right angles to each other. If magnetic deflection is used, the coils are usually outside the tube.

The deflector plates act on the beam in the following way: The beam is unaffected if the plates have no charge. If a positive charge is put on one plate, the electrons in the beam are attracted, but, due to their speed, the beam is deflected and not destroyed. The deflection is increased if the opposite plate is at a negative potential.

Now if an alternating voltage is applied between the plates, the light spot will move from side to side with the frequency of the alternations. If this frequency is greater than a few cycles per second, the spot appears as a straight line on the screen. If a similar voltage, but not necessarily of the same frequency, is applied across the other two plates, the beam can be made to form various patterns. Here, then, is an instrument which gives a beam, the direction and intensity of which can be varied in any desired manner, and so lends itself to the reproduction of television images.

Before going any further, it would be well to give an outline of the process of scanning. The principle behind scanning is that the picture is broken up into a number of horizontal zones or belts. Starting from the top left hand corner and going across, the portions of belt are converted to electrical impulses. When the right side is reached, the scanning is stopped, the beam flashed back to the left side at the beginning of the second belt, and the scanning started again. Proceeding in this manner, the whole picture is scanned. When the bottom is reached, the beam is flashed back to the top left hand corner, and the next frame is started. A frame is understood to be the picture formed during one complete traverse of the beam from the top to the bottom.

The requirement is therefore to direct the beam as shown in figure 4. There are two distinct processes. The first causes the beam to traverse from left to right at a steady rate, and when the right side is reached, the beam must be flashed back to the left side. This process must go on in definite equal time intervals. The second process must cause the beam to move from the top of the screen to the bottom and then the beam must be flashed back to the starting point.

To do this, two distinct controlling voltages are required for the plates of the cathode ray tube, one producing the horizontal motion, and the other producing the vertical motion. The graph of voltage against time must be of the form shown in figure 2. This form of wave is called a saw-tooth wave. Hence it follows from the above that two separate saw-tooth oscillators are required to produce scanning. The saw-tooth oscillator will not be described here since it would take more than an article in itself.

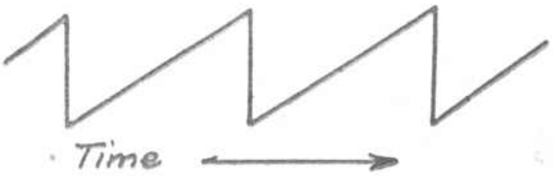


FIG. 2. SAWTOOTH WAVE.

The above system is called horizontal scanning, and has been adopted as standard. Less flicker is obtained by scanning each alternate line (i.e., the odd lines first, and then the evens), which means that each picture must be scanned twice before a frame is built up. The number of lines into which the picture area is divided is not yet final, but a temporary standard is 441 lines, with a frequency of 30 frames per second. With interlaced scanning, this means that the vertical sweep oscillator must produce a saw-tooth wave with a frequency of 60 cycles per second, while the horizontal sweep oscillator must have a frequency of 441 x 30 = 13,230 cycles per second.

For transmission and reception to be effective, the transmitter and receiver must be in absolute synchronism. That is, when the scanning beam of the transmitter is in the top left hand corner of the frame, this must also be the position of the beam of the receiver, and the two must keep in step all the time.

Synchronising has been one of the greatest difficulties in television, and it was recognised at the outset that it must be accomplished through the transmitter. The saw-tooth oscillators must be such that they can be synchronised by means of impulses from the transmitter, and for this purpose the natural period is made slightly longer than the accepted standard. The special synchronising pulse from the transmitter is then used to put the oscillators in step at the beginning of each cycle. The rectangular peaks of the waves shown in figure 5 are the synchronising pulses and are of greater amplitude than any possible image form, so that the receiver does not mistake the pulse for an image shape.

We now go on to the study of the television camera. Most of these cameras use the iconoscope. This instrument, invented by Dr. Vladimir K. Zworykin, combines thermionic emission, cathode ray beam formation, and photosensitivity, for the perception of optical images, and their conversion into an electric current. The internal arrangement of the iconoscope is as shown in figure 3.

An optical lens focuses the image of the scene on the mica plate. The front surface of this plate is covered with millions of very small independent droplets of silver, each droplet insulated from the

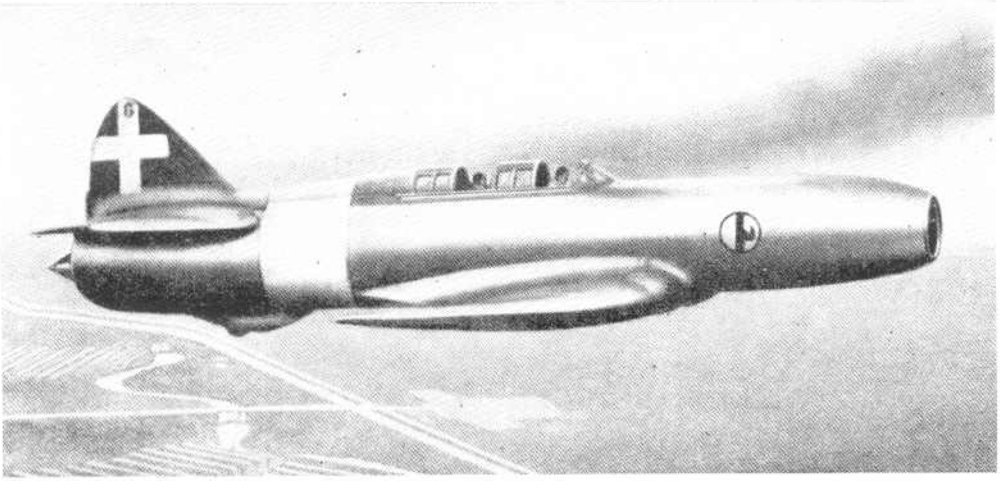
PROFESSOR
H. W. GARTRELL

THE death of Professor H. W. Gartrell on June 8 brought to a sudden end a life of great achievement and service. He had a brilliant academical record at St. Peter's College and at Adelaide and Columbia Universities. He worked in America for some years before he was appointed lecturer at the Adelaide University. Although he became head of the Mining and Metallurgical Department and later professor, he retained his interest in mathematics and the arts, and his wide knowledge was well appreciated by the professors and lecturers in these faculties.

His interest and sagacity impressed all students who sought his advice. He took a keen interest in ex-servicemen, and he was a foundation member of a Legacy Club, in which he worked with characteristic energy and thoroughness. He was also a member of the Amer. I.M.M.E. and a Councillor and Past President of the A.I.M.M.

During the war he carried out extra work in the Scientific and Engineering Manpower Committees and the Army Education Council. Although he had a serious illness in 1944, he carried on with his work unstintingly till the day of his death.

"Spog," as he was affectionately known, will remain in the memories of those who knew him as a wise, determined, unselfish worker for the good of all. We will not forget his great example.

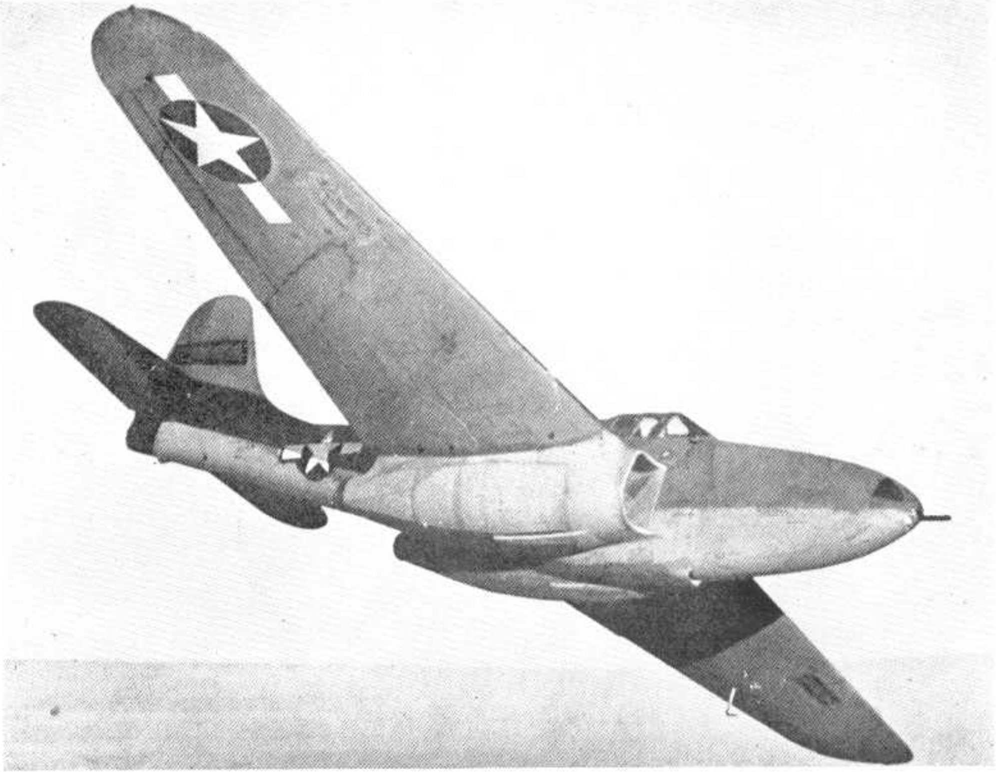


CAPRONI-CAMPINI II. This is not a true jet plane, as the compressor is driven by a separate radial engine.

(By courtesy of "Flight," London)

- Jet Planes -

These pictures show two early types of Italian and U.S. Jet Planes. Britain's supremacy in this field is emphasised by the fact that a British Meteor plane recently broke the world speed record with a speed of 606 m.p.h.



THE BELL AERO-COMET. An early type of U.S. Jet Plane.

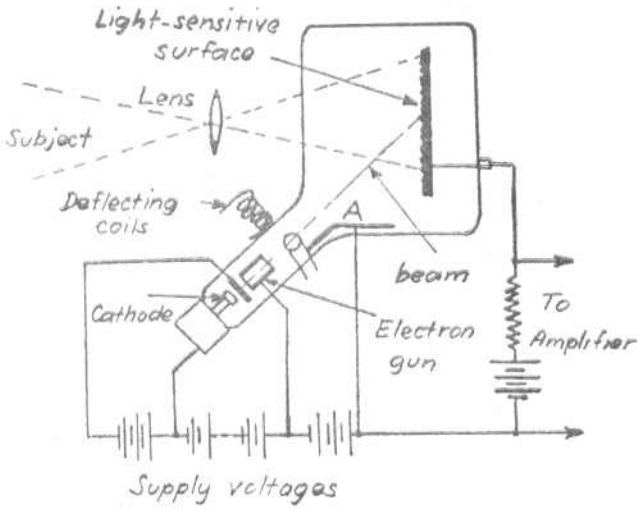


FIG. 3. THE ICONOSCOPE

other by the mica. On the droplets is deposited caesium, which is oxidised to caesium oxide. Each drop is so made photosensitive and emits electrons when illuminated, the number of electrons emitted being proportional to the strength of the light and to the time of its duration. On the other side of the mica sheet is sputtered a thin continuous film of metal, so that each droplet and the film of metal forms a miniature condenser, with mica as dielectric, capable of storing charge and of developing a voltage proportional to the stored charge.

When light from the object being televised falls on the plate, each droplet emits electrons proportional to the amount of light from the object. These electrons are collected by the anode coating (marked A) inside the bulb. The loss of electrons leaves the plate with a charge deficiency, and the deficiency is distributed according to the degree of light and shadow of the object. The charges cannot rearrange themselves, due to the fact that the droplets are insulated from each other.

The storage continues for 1–30th seconds, by which time the optical image has been converted into a charge image. The charge deficiency is replaced by a cathode ray (electron) beam. This beam is directed by the saw-tooth oscillators as described before. The beam travels across the top, is extinguished by the action of the control grid as it moves from right to left, and starts again, and so on.

There are 441 strips nominally, and the whole number is scanned in 1–30th seconds, hence each droplet has this time to accumulate charge deficiency, the electrons being replaced in a few millionths of a second.

The rapid replacing of the charge on each "droplet condenser" produces a rapid change in voltage between the droplet and the metallic film. This sudden change of voltage is conducted to an external circuit. Theoretically, the voltage change is proportional to the charge replaced, hence the voltage between the signal plate (metalfilm) and the collecting anode, A, changes in rapid sequence as each droplet is scanned, and so this voltage is an electrical representation of the optical image along each line scanned. The voltage changes are amplified and transmitted by conventional means.

It is almost impossible to obtain a perfect saw-tooth wave, the steeper side of the wave tending to be off the vertical, so that the return of the beam from right to left, and from bottom to top, takes a definite amount of time. As the beam flicks back, it generates unwanted impulses at the transmitter end, and a wavering trace across the face of the receiver screen. This effect is countered by sending an impulse representing "blacker than black" at the moment when the beam flicks back. These impulses serve the double purpose of blotting out the return trace and are used as the synchronising pulses for the system.

The receiver consists of a conventional circuit to receive the waves, two saw-tooth oscillators, cathode ray tube, etc. The beam of the cathode ray tube is made to move across the screen exactly as described before, and the receiver beam and transmitter beam are kept in step as described above, while the intensity of the beam is being changed in accordance with the signal produced by the iconoscope.

At present, the size of the screen is limited to about 15 in. x 11 in., due to the pressure exerted by the air on the evacuated tube, although larger tubes have been made. Another factor is the high operating direct current voltages, which become higher as the size of the tube increases.

It is interesting to note that about 260,000 significant variations of light and shade must be sent each frame. This means about 8,000,000 impulses each second. The highest possible number which can be sent at present is about 5 or 6 million. Even so the images sent approach in clarity the pictures produced in a movie picture theatre. The picture shown bears this out.

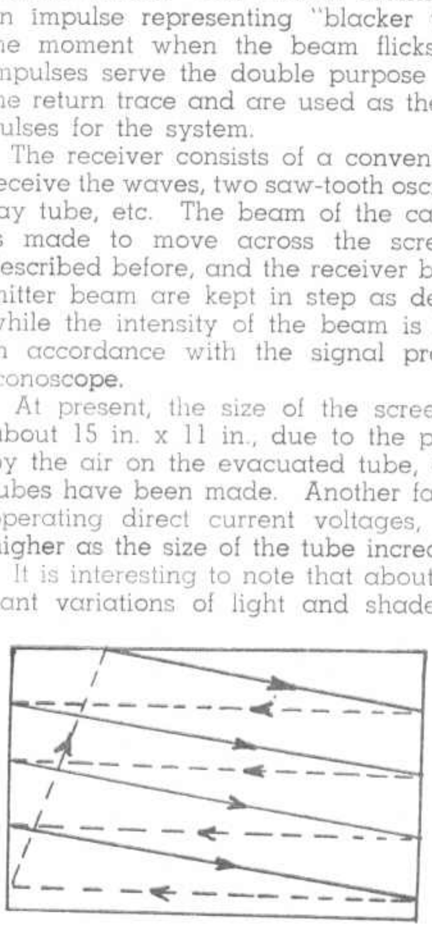


FIG. 4. SCANNING.

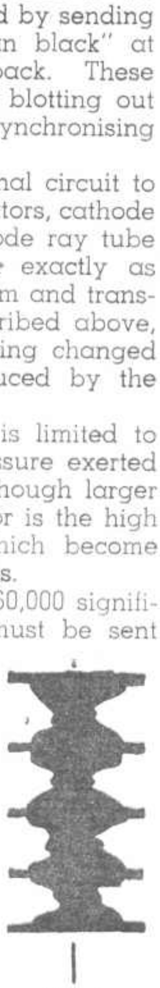


Fig. 5.

The above sketchy outline of television will serve to show that the whole problem is beset with difficulties and has reached nothing like the desired perfection at present. No mention has been made of colour television nor of many technical problems, but the discussion of these would take up more space than an article in this magazine would allow.

Aims in Engineering Education

By W. H. SCHNEIDER, B.E., B. Comm., Head Mechanical Engineering Dept., School of Mines

WAR is a tremendous stimulant. It calls forth not only enormous physical production, but also great mental achievements, such as scientific inventions (radar, atomic bombs, and the like), literature in the form of thought-provoking books and articles dealing with various phases of the conflict, changes in art and music, and even a new attitude towards religion. When peace cames—and the peace to follow this war has still to be won—there is a call, as there was at the end of World War I, for a mental stocktaking of the results of all the prodigious effort brought about by war. What are the lessons of this war? How will they affect the future? In the particular field of engineering education, were our graduates well equipped for the tasks of war? Are our students of the present day receiving the best kind of engineering education? If not, what changes can be visualised for the future?

The world of education is a world in conflict. It has been so ever since the beginnings of education. Plato founded the "Academy," the first European University, in Athens about 387 B.C. With Aristotle, he tells us of the disputes of his day as to the objects of education—whether useful knowledge, or reasoning power, or morals, or virtue, or a sense of excellence was the object of education. The moral is that we should plan our post-war changes provisionally and pragmatically and beware of snap judgments.

Has engineering education been a success? Suppose we take as our standard the lofty ideal set by the poet Milton: "I call, therefore, a complete and generous education that which fits a man to perform justly, skilfully, and magnanimously all the offices, both public and private, of peace and war." Has the engineer performed his duty **justly?** Has he stood between capital and labour, between employer and employee, between producer and consumer, between public welfare and private gain, and served with impartiality the interests of them all? The answer is—always and perfectly, **no,** but soundly and consistently, **yes.** He has done his work just as fairly and incorruptibly on the Morgan-Whyalla pipe-line as in New Guinea, on Australian military roads and bridges as in the field workshops of North Africa, on public works as in the establishments of private enterprise. On Milton's criterion of **justly** the engineer scores marks far above the average.

Has the engineer done his job **skilfully?** This war has been described as an engineer's war, and for some acceptance of this dictum might be taken as a sufficient answer to our question. But there is plenty of evidence to indicate that in most wars the engineer has been the chief reliance of military strategy. Xerxes ordered a bridge across the Hellespont; a storm arose, the bridge lost its boats and the engineers their heads. In this war, as in the last, success went to the side which could most skilfully develop engines of destruction and construction and most quickly organise manufacturing capacity. The god of war is on the side of the nation with the most skilful engineers, the heaviest industrial potential, and the best organised lines of supply. Finally, what about **magnanimously?** Does the engineer insist on being captain or will he play just as well in a secondary capacity? Will he let the team have the credit, or insist on the spotlight for himself? Can he applaud what men of other gifts and training contribute—the pure scientists, the lawyers, the doctors, the economists, the philosophers, the psychologists, and the politicians—or does he think the whole team should be engineers like himself? Does he put his work above his pay, his standards of excellence above a cheap expediency, his pride of achievement above applause, his integrity above a dubious fee or a shady profit? The world knows the answer—the engineer certainly does his work **magnanimously.**

There is no doubt about it—engineering education has been a success. Can we go higher? This is a question which is exercising the minds of engineering educators to-day. I believe that we can and that we should. My picture of the engineer of the future is that of a man who has received not only a good scientific and technical education, but has also a complete and generous education—a good **general** education. Much more time and relatively much more emphasis will, I believe, be given to humanistic studies—English, history, social institutions, economics, political science, and psychology—and to the sources of enjoyment and of spiritual enlightenment in literature, music, the drama, fine arts, religion and philosophy. Likewise, the fundamental sciences of physics and mathematics will be given greater emphasis.

There are solid and compelling reasons for giving the young engineer the soundest possible general education, and yet to do it within the framework of the engineering curriculum. In the first place, he is going to be not only an engineer, but a citizen, sharing equally with all other educated men the responsibility for national security, civic welfare, cultural advancement, and organised community life. These responsibilities are not peculiarly those of an elite group trained in other departments of the University.

A stronger reason, however, arises from the position of the engineer as a member of a great profession. Fifteen years after graduation, three out of four engineers will be engaged principally in directing the work of other men. Whether as engineers or managers, engineering graduates will be engaged upon work which demands not only an ethical standard of personal integrity, but also certain social obligations. The essence of a profession is social trusteeship. A clergyman is expected to be not only a spiritual adviser and minister, but also to unite with men of the cloth in giving voice to the public conscience and force to public morals. A lawyer is expected not only to be skilful in drawing legal instruments, in pleading cases, and in composing disputes, but also to join with his colleagues in guaranteeing standards of justice in the courts and in the legislatures. One expects a physician not only to be skilled in the arts of diagnosis and therapy, but also to guarantee, in company with his fellow physicians, the standards and facilities of the health services available to the community. Similarly, an engineer is expected not only to be expert in the technique and economy of materials and energy, of structures, products, and utility services, but also, in co-operation with men of other professions, to guarantee that society will reap the fruits of scientific advance and technical progress in general community welfare. To an increasing degree, engineers will have to hold their own in teamwork with men trained in other professions. This can only be made possible through the command of a common language and a common standard of values.

In purely engineering studies, the permanent values are not in mastery of present practice and details of technique which are growing obsolete before they are recorded in text books, but in principles and relations which are of enduring validity. Steam turbines may yield to gas turbines and petrol engines to jet propulsion, but Newton's laws of motion and the first two laws of thermodynamics will stand and we are still far from exhausting their potentialities. In a University engineering course, instruction should be concentrated on those essentials which, if not acquired at that stage, never will be acquired. Technical details, which will automatically be picked up in a student's subsequent career, are useful in stimulating interest or in illustrating principles, but apart from this they are of secondary importance. Education does not consist in the memorisation of a number of facts and formulae, useful though these may be when leavened with intelligence. Education at its best should aim at something much deeper and more enduring, and the good of education is the power of reasoning and the critical, detached and objective habit of mind which remains when all efforts of memorisation have faded into oblivion. For the student of engineering, this means that the permanent values of the degree course do not lie in any detailed knowledge of subject matter or the technique of engineering practice, but rather in a mastery of the engineering method, that is, a way of using knowledge rather than knowledge itself. The engineering method is a method of analysis, of procedure, and of evaluation applicable to new problems rather than a familiarity with processes and standard solutions already deduced; it is not concerned with subject matter, but is a process that cuts across the various areas of subject matter; it is an active process, applied by the engineering student to problems and projects of the right degree of difficulty, and not a passive process of hearing lectures and witnessing demonstrations. The engineering method draws on fundamental principles and their corollaries, on the basic assumptions used to make complex situations manageable, on the information derived from empirical observation, on the codified experience embodied in standards and recorded in handbooks and manuals; it uses judgment factors beyond the limits of rational analysis. Finally, the engineering method uses the criteria of cost and financial return—the evaluation of the comparative economy of alternative projects. It is this method, with its depth, breadth, and comprehensive viewpoint, which distinguishes engineering from science and provides one way of distinguishing an engineer from a mathematician or a biologist.

If the University engineering course of the future is to include more humanistic studies in addition to the present aim of a well rounded mastery of engineering fundamentals, with its emphasis on the engineering method, it is desirable that some thought be given to the selection of qualified students. In the past, less than half the students entering the engineering school have graduated at the end of the four-year course. The quickest, cheapest, and most effective way to increase the capacity of the engineering school to cope with rising post-war demands is to select material that provides better educational risks. It is to be hoped that the new matriculation requirements will go some way towards achieving this end.

The engineering graduates with a good general education and having a mastery of engineering fundamentals, but lacking specialised knowledge of technical details of processes and practices, will necessarily appear to subsequent employers as lopsided creations. It will be for the employers to complete the educational process and rectify this lack of symmetry. Engineering teachers hope for sympathetic treatment of their students in this process. They trust that it will be done by filling in the hollows rather than flattening down apparent excrescences. These bumps ought not to be treated as indications of a swelled head; they are bumps of knowledge of a high kind and as such are deserving of respect. It is not claimed that our engineering students leave us as full-fledged engineers in any one of the major branches of engineering—mining, metallurgy, civil, mechanical, electrical. They are not narrow specialists in any one direction, but they possess a versatility and balance of mind which enables them to strike out with almost equal facility along any line they may subsequently be called upon to pursue. Premature specialisation cramps the imagination, and is destructive to the length and breadth of mental vision. The man who has had his foundations of training and belief widely and deeply laid will overtake and surpass at his own game one of equal native intelligence, who has had his imagination cramped by premature specialisation.

SOME ENGINEERING ACHIEVEMENTS OF THE WAR

By P. BROKENSHA

ALTHOUGH money can never be found for it in peace time, scientific research has received a tremendous fillip from the war. The outstanding achievement, of course, is the extraction of atomic energy from uranium. This will have an enormous effect on all branches of science and engineering when, and it will surely come, it has been learnt to control this terrific energy. However, in almost every field of investigation something notable has been done. We have seen the science of aeronautics develop a hundred fold in the last five years culminating in jet propulsion. Radar has been developed and there are many radio and electronic devices which will appear in peace time.

Plastics have been developed a lot during the war, and the more conservative civil engineers have developed such masterpieces as Bailey bridges, floating seaports, prefabricated roads and airstrip, and a pipeline under the English Channel, to mention only a few.

Radio Location.

One of the most outstanding achievements of the war has been the development of radar. It has developed so rapidly that at the present time it is used for a multitude of purposes which range from spotting ships at sea to bombing a target from 20,000 ft. through fog or darkness. Fitted to fighter planes as well as on the ground, it was largely responsible for winning the Battle of Britain.

To understand its elementary principle we may consider it to be made up of three parts (see sketch). The transmitter generates high frequency radio pulses and its aerial is directional, so that the direction of any target can be found. Next is the receiver, which picks up the direct and reflected pulses from the transmitter. Then we have the indicator. The essential part of the indicator is a cathode ray tube (see sketch). An electron "gun" shoots out electrons and these are deflected by a pair of horizontal and vertical plates and finally fall on the fluorescent screen where their path is visible. The horizontal plates are fed from a time base, while the vertical plates are fed from the receiver.

Let us suppose that we wish to find the distance and direction of a ship we suspect is off the coast somewhere near our radar station. The direction part is simple. We merely rotate our transmitting aerial until we get the largest echo on the indicator, then the aerial will be pointing at the ship. The distance away is simply read as the distance between two kicks on a horizontal line on the fluorescent screen of the indicator. This is how it is done.

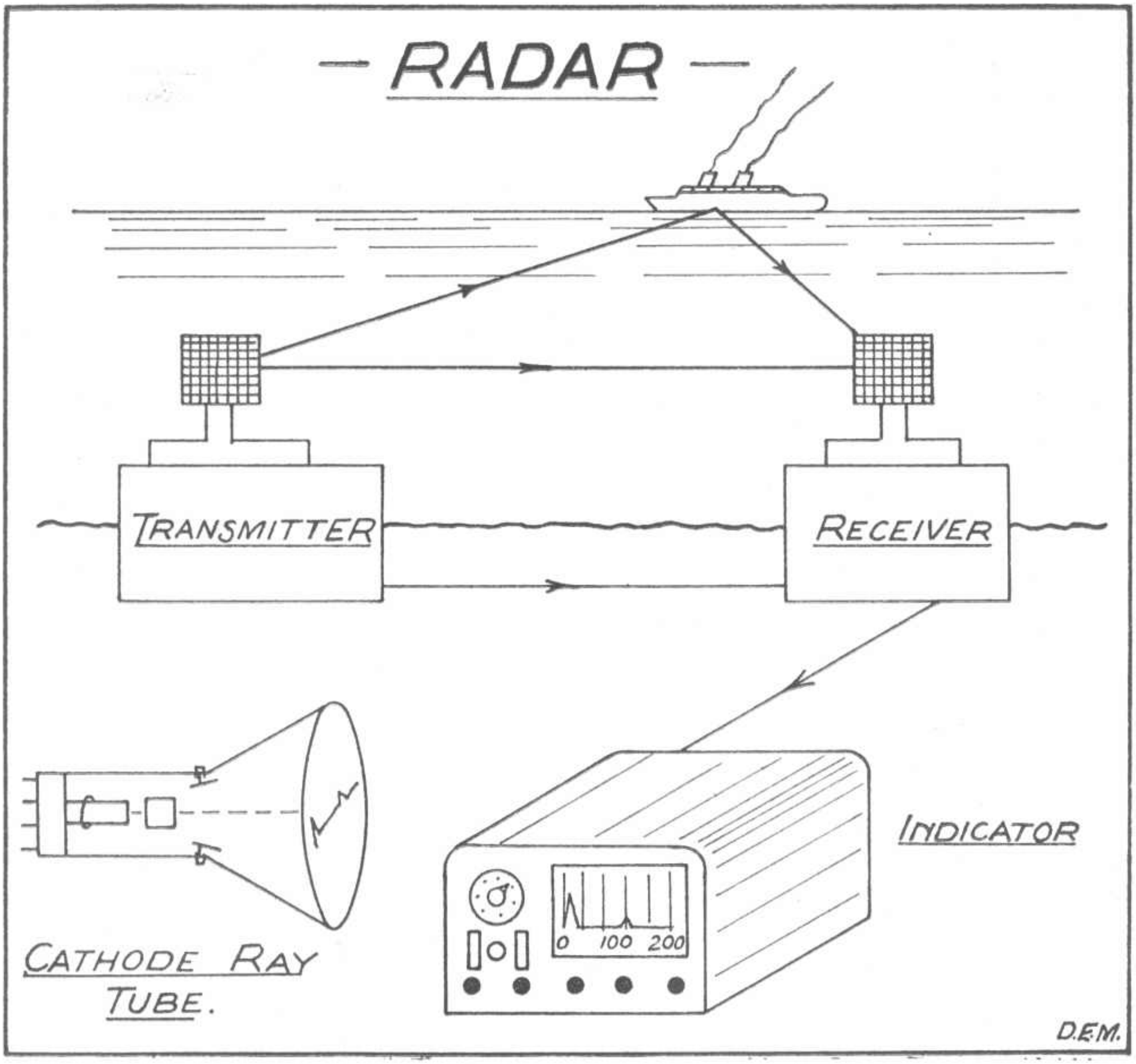
The transmitter sends out a pulse, which is immediately picked up by the receiver, which, in turn, gives a "kick" on the indicator screen. The pulse travels out and hits the ship, some of the reflections are picked up by the receiver, and the indicator screen shows another, yet smaller, vertical kick. As radio waves always travel at 186,000 miles per second, the time between the direct kick and the reflected kick will be proportional to the distance travelled. The time base mentioned above, which feeds the horizontal plates of the C.R.T., moves the indicator trace a certain horizontal distance in this time, and this is calibrated on the screen as miles.

That is a brief outline of the first principles of radar. Its applications and refinements have been the subject of intensive research by scientists in all countries and their quest has led them into many new fields, which, it is thought, may revolutionise post-war radio development.

The Pipeline Under the Channel.

The maintenance of a steady flow of fuel to France after D Day was a vital necessity. British engineers solved the problem in a unique way by building a pipeline under the Channel.

The most notable part of the operation was the development of an amazingly flexible five inch outside diameter pipe. One type consists of a three



inch diameter lead tube bound with two layers of adhesive tape and then wound with two layers of steel ribbon wound clockwise and counter clockwise. This in turn is covered with a layer of bitumenised hemp and wound with steel wire and finally covered with a layer of bitumenised hemp to bring the diameter up to five inches.

The pipeline was transported on large floating drums (see picture) and was laid by a cable ship. The pipeline was unwound from two large tanks, 50 ft. in diameter and 40 ft. deep, which rotated to facilitate unwinding.

Three pipelines were laid. Of total length 200 miles were laid and were pumping up to a million gallons a day to France.

Cotton Airstrips.

In the sticky mud of Burma it was impossible to construct airstrips where planes could land or take off after any rain. Meshed steel plates were tried as a surface, but were not entirely satisfactory, as often the steel mats sank well out of sight in the mud.

The problem was solved by a Canadian engineer, who proposed that cotton impregnated with bitumen should be used. It was used and was found to be very successful. Rolls of cotton or burlap, about three feet wide, are impregnated with bitumen and ferried to the site by air. There the sheets are unrolled, overlapped, and stuck together simply by applying a solvent, such as fuel oil, to the joints. This made a strong waterproof surface for the airfield. The method is called the P.B.S. and has speeded up the construction of airfields by days and weeks of valuable time.

JET PROPULSION

By P. J. PANNELL

The war years have seen many new weapons, but the one which has caught the public attention and interest is the development of jet propulsion as applied to aircraft.

NOTE carefully, "development," because the history of jet reaction shows us that Hero first used it in his "engine." Newton is also credited with a jet propelled vehicle, although some doubt exists whether this genius is responsible for it or not. The arrangement is that a jet of steam from a boiler mounted on a four-wheeled cart is blown in one direction, and the vehicle "moves" in the other. It is very doubtful if the vehicle moved at all, and if so, only for a very short distance. However, the point is that possibilities were known to exist for jet reaction to provide motive power for travel.

The Italians, who, for an obvious reason, wanted their aeroplanes to be the fastest in the world, experimented with two types known as the Caproni-Campini I and II or C.C. I and C.C. II. They reported to the rest of the world that the plane's performance was equal to that of orthodox machines, and then remained remarkably silent. However, it was not until the war demanded faster, more powerful planes that any really serious work was done on jet propulsion, and it is only just to say that Britain's lead in this field is due primarily to the tremendous efforts of the late Group-Captain Whittle.

The idea of jet propulsion, broadly, is that a large quantity of air is sucked in, compressed, passed on to a combustion chamber, where a fuel is burnt and the resultant gas is allowed to expand through a nozzle to the air, thus producing a jet reaction. Generally a single or double stage axial flow turbine is introduced between the combustion chamber and the nozzle. This provides power for the air compressor (centrifugal or radial type), which is co-axial with the turbine.

But let's look a little deeper into the question. Doesn't the air, after combustion, become extremely hot? Right; and therefore it is necessary to keep the temperature of the gases down. After all, you don't want your turbine melting before your eyes.

Doesn't the turbine take a lot of the power from the jet? Right; it takes about 70 per cent.-75 per cent of the energy in the jet.

How are you going to start your unit? We'll have to put in a separate starting motor, and that means extra weight to carry, and we want to keep the weight as low as possible.

Isn't the fuel consumption high? Right; it's very high. An approximate figure is 0.8 lb. per b.h.p. hour.

Well, from these few observations it would seem that the idea has more drawbacks than advantages; but let's look at the other side of the question. Let us tear up the arguments that have been given and then offer some constructive facts and

First, let us consider the gas temperature. Turbine steel is being produced which will withstand a continuous temperature of 1000 degrees F. and still retain a tensile strength of 12 tons per square inch.

Secondly, present day jet propelled planes have a reported speed in excess of 600 m.p.h. The unit in these planes is of the order of only a half the weight of the orthodox reciprocating engine. Hence this reduction in weight of the engine tends to counterbalance the effect of the weight of extra fuel and the starting motor.

The main consideration we must keep in mind is: What is the overall effect on the design of a plane incorporating jet propulsion instead of the orthodox engine?

First, the most striking feature is that the orthodox engine is reciprocating, thus producing vibrational stresses; and jet propulsion engines are pure rotation and need no strengthening against vibration in the fuselage of the plane. This consideration shows us that we will certainly have a consequent reduction in weight of the plane.

Because we need no clearance for propellers, we can reduce the size of the undercarriage considerably—less expense and less weight.

The orthodox machine uses an 100 octane fuel or better. This fuel is remarkably inflammable and hence is dangerous to carry around in a plane. On the other hand, the jet propelling unit can be run on "safe" fuels—i.e., heavy oils and paraffin—which are not nearly so dangerous and are considerably cheaper.

Another advantage is that the laminar flow aeroplane. This wing section tends to give us the least resistance to flight, and hence raises the speed of the plane.

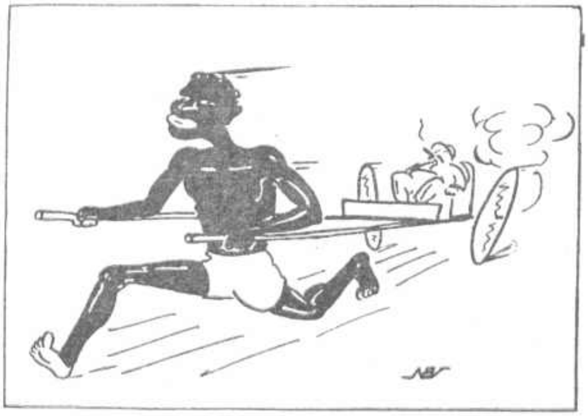
The present day type of propeller has a high efficiency at low altitudes, but this efficiency falls off the higher the plane goes. On the other hand, the jet unit's efficiency rises with increase in altitude.

This fact automatically presents itself as a useful compromise between the two systems. Put two contra-rotating propellers on the axis of the turbine and compressor, and use the jet as auxiliary power at lower altitudes and as the main source of power at high altitudes. This possibility has been reported to be highly satisfactory and experiments are being carried out to find its maximum potentialities.

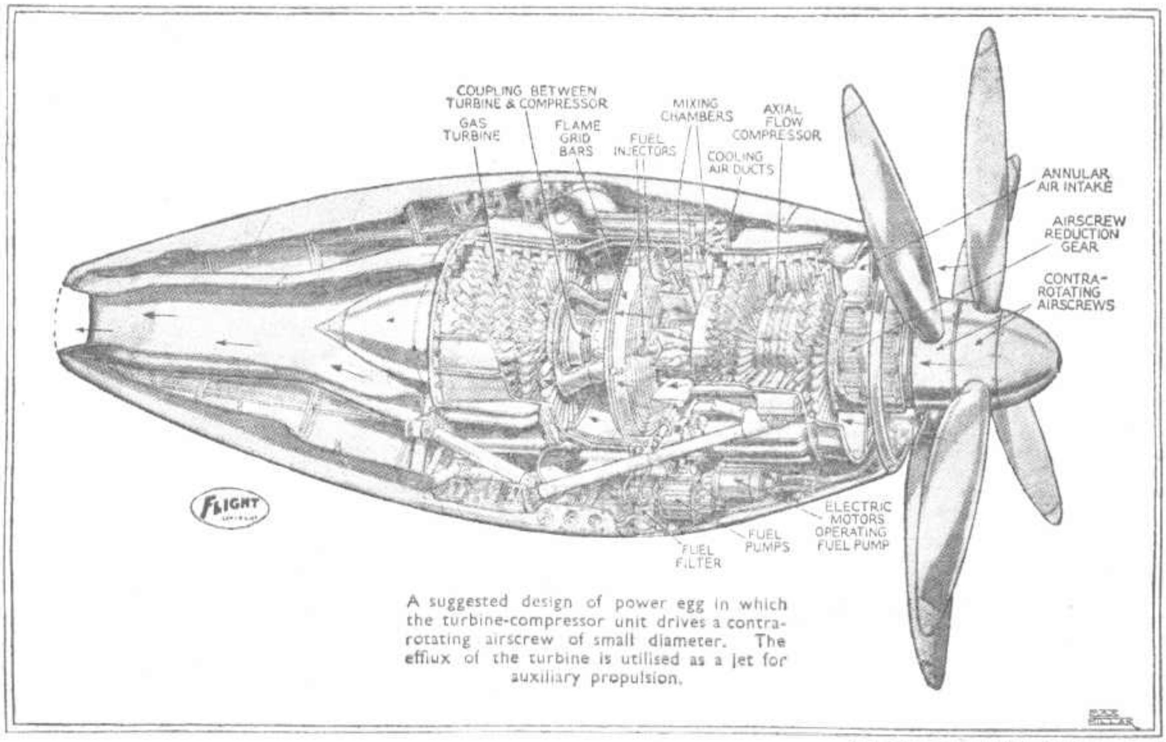
One aspect of jet propulsion systems as yet hardly touched is that of boundary layer control—that is, the reduction of the energy left in the air in the form of turbulence by the plane's passage. This can be done by controlling what is called the boundary layer of air on the plane surface—i.e., instead of disturbing the air, to allow the plane to slide through with minimum disturbance and hence leave less energy behind in the form of eddies. One suggestion is that high velocity gas is bled from the jet and released tangentially to the plane's surface, thus preventing the air from breaking away from it. This inevitably must reduce the surface resistance and thus increase the range and speed of flight.

However, we must not be too optimistic about the future for jet propulsion; much hard work and, alas! much money will be needed to develop the unit to its maximum efficiency; but a good start has been made.

Prominent experts declare that jet propulsion is here to stay. Dr. Ricardo, a giant in research in internal combustion engines, declared that the aero-engine has reached its limit in power output, and added further that the field for greater power output lay in internal combustion turbines and jet propulsion.



JET (Black) PROPULSION



A suggested design of power egg in which the turbine-compressor unit drives a contra-rotating airscrew of small diameter. The efflux of the turbine is utilised as a jet for auxiliary propulsion.

(By courtesy of "Flight," London.)

SHELL
was First to make Possible
100 OCTANE AVIATION GASOLINE

Since the beginning of Aviation, Shell has played an all important part in its progress—pioneering routes, and arranging supplies for almost every international flight of importance.

As in the past, so in the future, Shell will always be in the forefront of Aviation development.

SHELL AVIATION GASOLINE
AND
AEROSHELL

You can be SURE of SHELL

THE SHELL COMPANY OF AUSTRALIA LIMITED (Incorporated in England) S.A. 442

MOUNT PAINTER

By L. T. NICHOLLS

When the atomic bomb was being developed the whole allied world was combed for suitable uranium ore deposits. Here in South Australia several deposits were investigated, the main one being Mount Painter, with the view of being used in the production of atomic bombs. Mr. Nicholls is one of a party of Adelaide students who were specially flown to Mount Painter to undertake special work there.

MOUNT PAINTER is in the North Flinders, roughly 30 miles west of Lake Frome and 100 miles east of Leigh Creek. Uranium is undoubtedly the element from whose partial destruction the new source of power is realised. Uranium ores occur at several places in S.A., notably at Radium Hill, about 20 miles from Olary, on the Broken Hill line, Cowell, on the West Coast, Moonta and Mount Painter. None of this has been mined economically in any quantity, although some years ago about 20 tons of hand-picked uranium ore were shipped out by camels from Mount Painter, only a few hundred tons being mined altogether. The eyes of this deposit were picked out, as recent development has proved.

Mount Painter itself stands, roughly, seven miles from the edge of the plain, and rises to nearly 3,000 ft. Although not high, the ranges are very rough and in parts extremely picturesque. They tend to lose some of their attraction, however, after a series of droughts and in the middle of summer.

The history of the place goes back nearly 40 years, to when the manager of the station in which the area is situated did some exploration in the hills. Although without geological training, he was keen enough to observe traces of the bright green mineral, torbernite, and had them identified in Adelaide. This led to the opening of the main Mount Painter mine. Several other deposits within a radius of five miles were tested, but none produced any appreciable tonnage. Since then much attention has been paid the geological features of the district, but until recently no further attempts have been made to mine the uranium ores, partly because of their low grade and also because the world demand for the element has been rather small, and most requirements were met by Canada.

The recent developments started last year, when Mr. Curtin was asked if Australia would investigate her uranium deposits, not so much because of a shortage then, but pending its utilisation in the war, when there might have been a sudden demand. As it has turned out, Australia's only two important deposits, Mount Painter and Radium Hill, have not produced enough ore to warrant large-scale operations, and their future depends chiefly on the uses to which uranium can be put after the war.

Prospecting plans were made to cover the two places. Radium Hill was a comparatively simple job, since most of the country was easily accessible by motor and the geophysical prospecting apparatus was carried on the back of a truck, which made the work easy. The old mines were dewatered and investigated. Mount Painter was another matter, owing to the ruggedness of the country and the fact that the known deposits were of an unusual character, which made it difficult to predict in what features the minerals would occur and whether secondary enrichment could be expected, either at the surface or deeper down in the deposits. The plan was that of a modern prospecting party, namely, to make an aerial survey, taking stereoscopic photographs of selected areas over several square miles. From these the field geologists could pick likely areas for investigation, thus narrowing down the field of operations. On their recommendation the geophysicist made a thorough survey. One place picked out for this was East Painter, four miles from the main camp. The instrument used was a Geiger-Muller tube with an amplifying system for measuring count rates produced by the bombardment from radio-active emanations. This could only record occurrences of radio-active minerals to a depth of a few feet, and so a prospecting shaft was sunk at a point where the surface indications were best. The surface showing was good and rock going up to one per cent. torbernite (hydrated copper uranium phosphate) was obtained, but at 80 ft. it had practically petered out. It was thought the occurrence might have something to do with the shear zone in which the mineral occurred, but there is no proof of it.

Water required for drilling at this and another deposit further north was carried from the camp by camels. It is surprising that they are the animals best suited for this work. They can carry 600 lb. over very rough trails without an unreason-

able amount of complaint, and keep in good condition on the rough bush growing in the hills.

The old No. 6 workings at the main camp were opened up by the S.A. Mines Department in order to get information regarding the deposit, and also in the hope that ore like the first discoveries might be obtained. In places in the previous workings solid walls of atunite (hydrated calcium uranium phosphate) were found. A motor road was put into the camp. This required the blasting of rocks in the creek, and these were then cleaned up with a bulldozer, making a tolerable job of it. Mr. J. P. Morgan, our ex-president, was in charge of mining operations for the first few weeks. When we saw him first, he was busily engaged in resoling his boots, and assured us that this was one of the most important engineering operations that had to be learnt since soles only last about a week up there.

The actual mining undertaken was the opening up of three adits driven at 50, 100, and 150 ft. below the collar of the shaft and then join these by winzes to get further information. The shaft collar is 270 ft. above the creek bed, in which the camp stands. A plant with two large air compressors and a generating set were installed below the mine openings. Water for drilling and boring was supplied from a bore put down by churn drill right at the camp. Diamond drilling was carried on underground at the same time as mining proceeded. The difficulties to be overcome were numerous, and it was largely due to Mr. Morgan's energy and skill that the work was successfully started. One difficulty was the lack of standard equipment, which is a great drawback in a small show. At one time the men were boring blast holes above their heads with jack hammers because there was no steel stiff enough for the heavy drifters, although there was a superabundance of detachable bits of all sizes. The men lived in wood and iron huts and in tents. A large flyproof mess hut was built and a wireless was provided as chief amenity. An adequate water supply was a problem, as the rainfall of the district has only been about 5½ inches average for the last 20 years, and a large quantity was used underground in addition to the domestic requirements for a camp of 60 men. The main camp was able to get enough from bores near at hand, but the east camp was still carting water several miles by truck when it was cleared up.

Supplies to the camp were brought the 100 miles from the railway at Copley by motor truck. Men and small pieces of equipment were also brought by air to Balcanoona Station, 30 miles away. The trip into Copley is interesting and the hills are magnificent in parts, but the station country is rather a sorry spectacle, as the saltbush is disappearing off much of the land, causing it to drift badly. Even reducing stock numbers will hardly restore the country now. Rabbits become a menace when good conditions prevail, and are one of the biggest factors in spreading desolation. The mining industry may open up a future for the country, there being numerous occurrences of copper, talc, magnesite, and barytes, in addition to uranium ore, but up to date none of these have been able to compete with richer deposits nearer the main markets.

PAST MEMBERS OF THE A.U.E.S. WHO FELL IN WORLD WAR II

Bullock, F. D. R.
Cooper, M. W.
Cowan, C. R.
Cowell, D. B.
Cuming, R. B.
Fielding, A. W.
✗ Gerney, J. S.,
Goodefellow, J. N.
Gray, A. F.
Hart, P. W.
Haste, J. A.
De~~Hay~~, D. G.
Ifould, A. H.
McKenzie, J. A.
Nicholls, W. J.
Nitschke, J. E. ✗
Penn, T. W.
Raftery, J. A.
Robertson, J. H.
Robbins, T. F. ✗
Shearer, B. W.
Tuck, D. T.

This list is complete as far as we are able to ascertain.

HAWKESBURY RIVER BRIDGE, N.S.W.

By D. H. TYLER

One of the largest structural undertakings built recently in Australia is the bridge over the Hawkesbury River, at Peats Ferry, N.S.W. It incorporates many new features in design and construction and these are outlined in the following article.

THE new bridge was opened in May, 1945, and was designed by the Department of Main Roads of N.S.W. The two most exceptional features were: (1) Electric arc welding was used in the fabrication of all members of the two main trusses, each 440 ft. long. (2) An open dredged caisson type of foundation, which reached a depth of 241 ft. below water level, was used. This is the second deepest caisson of this type ever used.

Site Conditions.

On the south side the bank of the river is very steep and rocky, with the deep portion of the river adjacent to it. On the north side the river is shallow for some distance from the bank, with mud flats exposed at low tide, whilst the bank itself is gently sloping. At this site the river is 2,600 ft. wide, but a rock fill embankment on the north side reduced the actual length to be bridged to 1,990 ft.

Foundation Conditions.

Borings were taken to a depth of up to 200 ft. and disclosed mud, shells, sand, and clay. There was a complete absence of bed rock, so it was obvious that costly pier construction would have to be used. Short spans supported on piles were practicable on the north side, where the water is shallow and the mud suitable for pile driving. This portion was bridged by 90 ft. steel plate girder spans. The deep portion was bridged by two K truss spans, each 440 ft. long, supported at the centre on an open dredged caisson foundation.

Substructure.

The piers, which are numbered 1–18 from the south side, involve many unusual features in design and construction.

The forms of substructure provided for in the plans were:

(1) Abutment A—Founded on dry rock.
(2) Pier 1—Founded on rock below water level.
(3) Pier 2—An open dredged caisson.
(4) Piers 3–11—Founded below mud level on nests of reinforced concrete piles.
(5) Piers 12–18 and abutment B were reinforced concrete pile trestles.

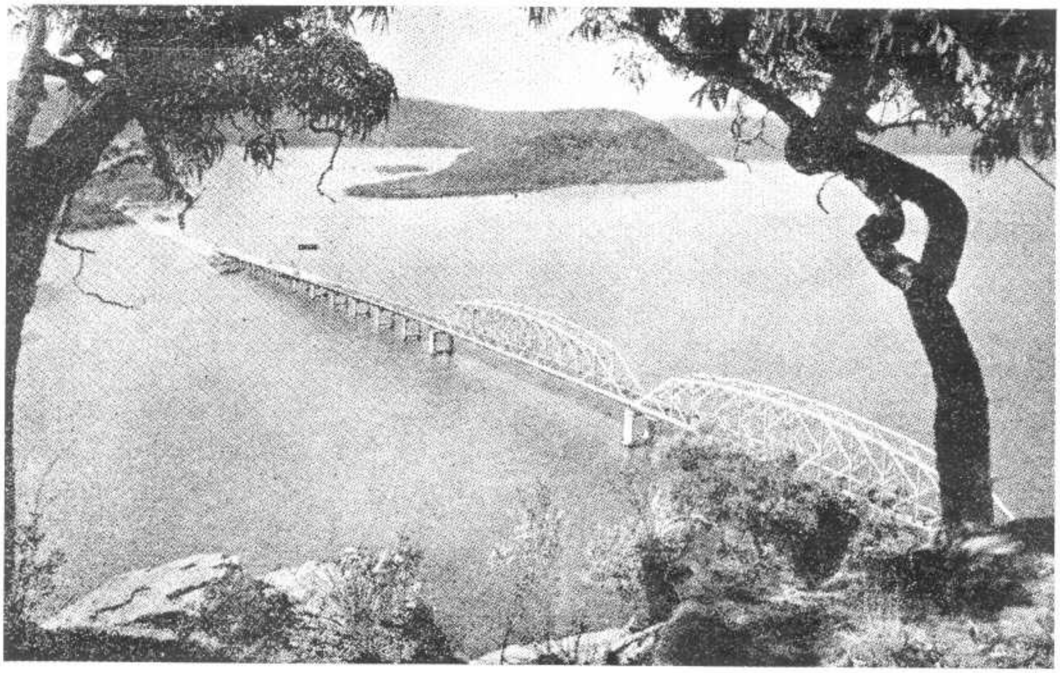
The excavation for pier 1, on the water's edge was begun first, and proved to be a difficult job because fissures in the sandstone allowed water to pour into the foundations. These fissures were very difficult to seal, and after a diver had explored the river banks in an effort to locate and block the sources of leakage, the foundation was eventually excavated into solid rock 12 ft. south of the site planned.

Pier No. 2—The open dredged caisson was the major item of substructure. It is located in the centre of the deep water channel, and was intended to be founded on a bed of sandstone some 170 ft. below low water level. The caisson is essentially a reinforced concrete shell, with a steel cutting edge. It is sunk by excavating mud from the inside and allowing the weight of the shell to sink it as excavation proceeds.

This pier is 23 ft. wide and 51 ft. long, with semicircular ends; the side walls are connected by three transverse walls dividing the interior into four wells. The whole pier relies for its support on its large base area assisted by the frictional grip of the outer walls. The caisson was built on and launched from a large punt. After landing on the bottom of the river the bulkheads were removed and dredging commenced. By April, 1940, the shell had been built up to 129 ft. and the cutting edge was 50 ft. below the river bed. On the evening of April 11 the caisson took a run of 53 ft. and dropped right out of sight 45 ft. below water level. Fortunately, the drop was found to be exactly vertical.

Location of the sunken caisson and determination of a method of building on to it presented a unique problem. A new section of caisson was built on to a punt, floated as before, and successfully landed on top of the sunken section. The two were joined with concrete poured under compressed air. Forewarned by this experience the engineers in charge were not dismaqed when at a later date the caisson sank 31 ft. and again 28 ft. They had built the caisson up more than usual and when it sank it remained only a few feet below water.

When all excavation was complete and the bottom cleaned up, all mud and silt being removed by an air lift pump, the caisson was found to be bedded half on rocks and half on a bed of coarse



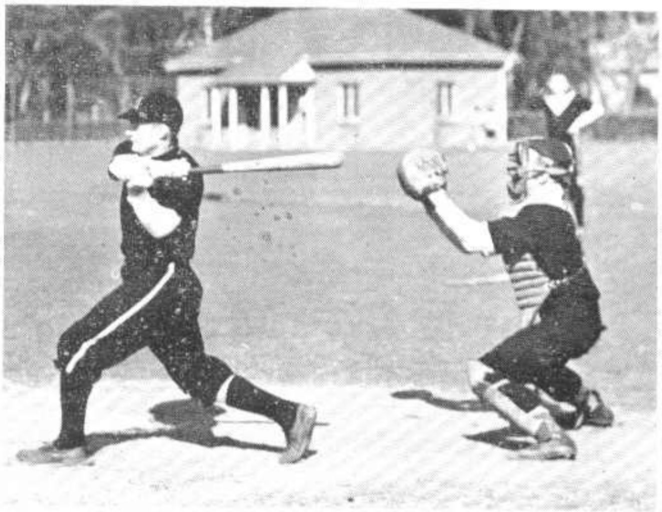
PEATS FERRY BRIDGE, LOOKING SOUTH.

LIFTING TACKLE FOR CONCRETE PILES.

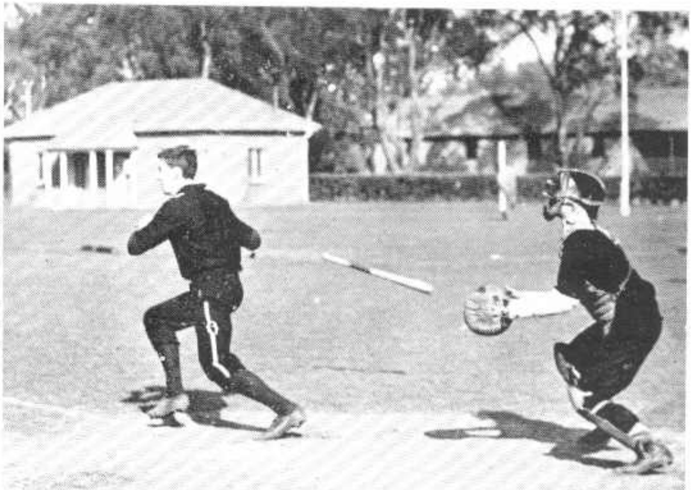
ENGINEERS AT SPORT

J. De Cure winning the 440 Yards Championship.

Left: Engineer J. L. Graham chases the ball in the Rugby match, University v. Port Adelaide.



J. Fahey, Captain, A grade baseball team.



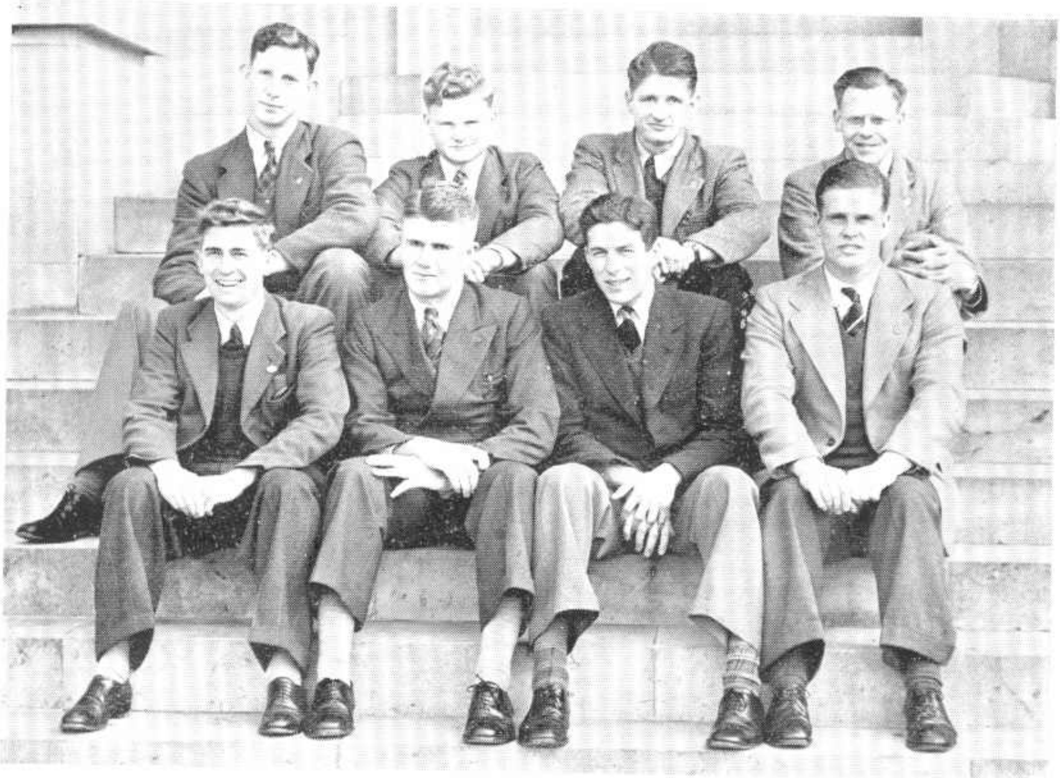
P. Brokensha sets off for first base in A grade baseball match.

W. H. Marker marks a ball in the Engineers v. Science match.

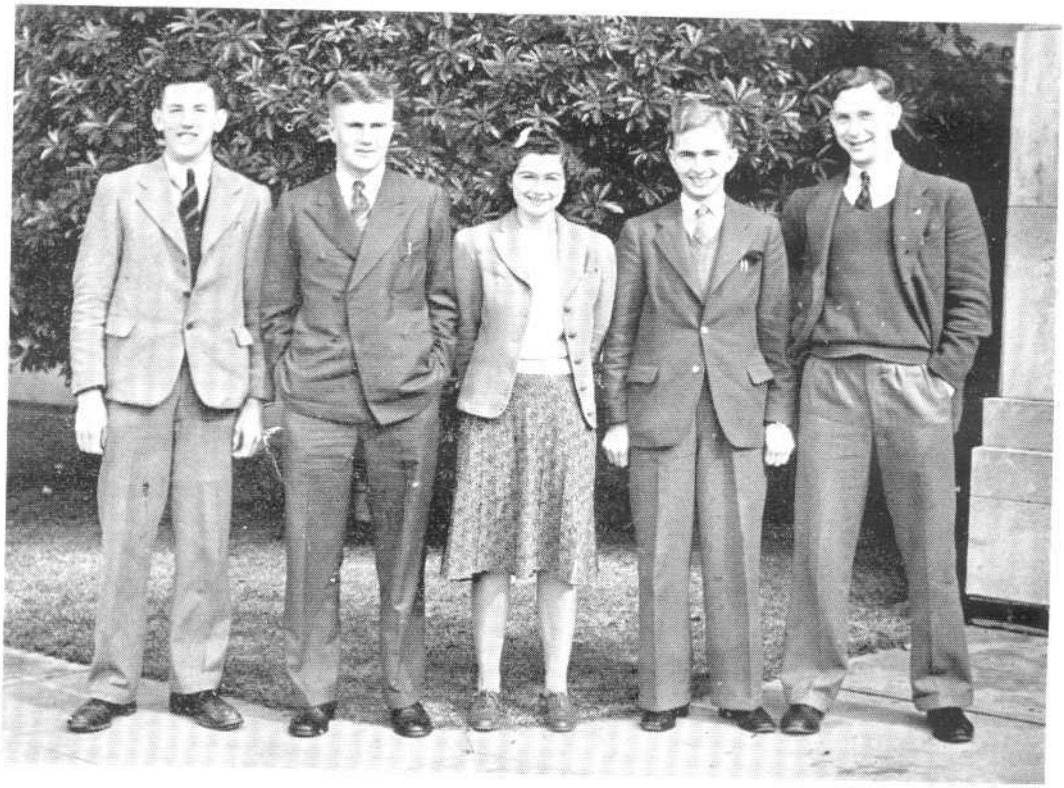
R. G. Cowper, Captain, Engineers' football team and A grade rover.

J. L. Whittle, A grade cricketer.

K. R. Stevens, University Mile Championship.

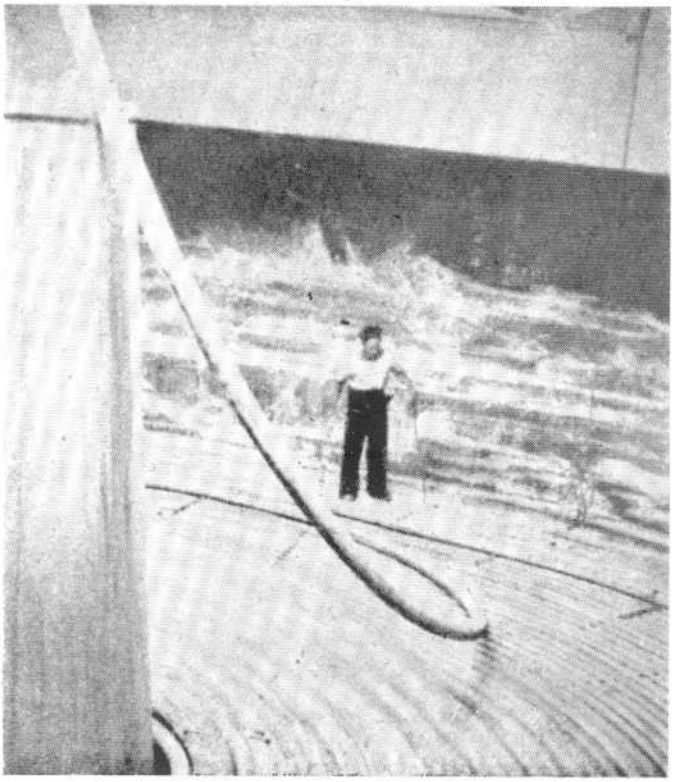


1944-45 A.U.E.S. COMMITTEE.
Back Row: P. G. B. Claridge (Secretary), P. K. Hosking, G. R. Cowley, L. R. Trott.
Front Row: D. H. Tyler, R. W. Parsons (President), L. T. Nichols, J. L. Whittle.

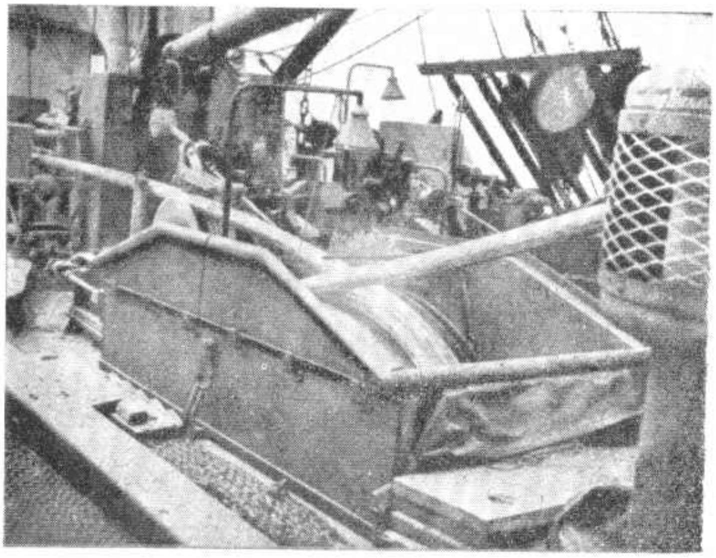


MAGAZINE COMMITTEE.
P. Brokensha, R. W. Parsons, Miss M. E. Angas, J. C. Rounsevell, P. G. B. Claridge.

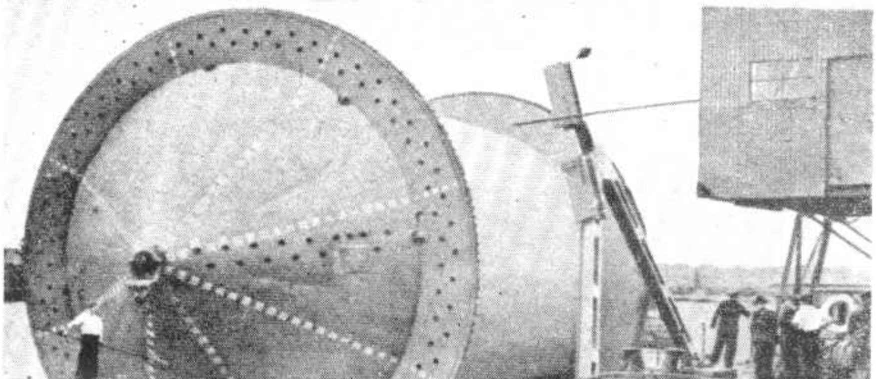
PIPELINE INTO FRANCE



CABLE SHIP: Rotating drum in the hold unwinding pipeline.



PIPELINE being paid out from the Cable Ship.



STEEL TRANSPORT DRUM, 30 ft. in diameter.

sand and gravel. The deepest part of the excavation was 241 ft. 4 in. below low water level. This is within 8 in. of the deepest bridge foundation of the world, at San Francisco's Oakland Bay bridge.

Special drop bottom buckets were used to put a sealing plug of concrete 26 ft. deep in the bottom of the caisson. The concrete was placed under water and had to be poured continuously. The operation of pouring 582 cubic yards of concrete was the biggest continual pour on the job. A top sealing plug was then poured to form a platform on which the pier shafts were built.

Piers 3 to 11 were founded on groups of reinforced concrete piles 20 in. square, and varying in length from 83 to 110 ft. For each pier a sheet steel coffer dam was built and the silt of the river bed excavated for a depth of about 20 ft.

The piles weighed up to 24 tons each, and were designed to be lifted at certain points only, as they would rupture under their own weight if supported only at the ends when in the horizontal position. A special gear for lifting the piles was designed by Mr. Fargher, of the South Australian Railways (see illustration). For driving an 8-ton hammer and long iron bark followers were used.

The bases of piers 3 to 11 were built over the tops of piles inside a diving bell, which in this instance was a large welded steel working chamber filled with compressed air. It was 51 ft. long, 30 ft. wide, 15 ft. high, and weighed 40 tons.

Superstructure.

It was finally decided to use a through truss, with the top chord a series of straights, and using the K system of bracing. All shop fabrication was done with electric arc welding, the field joints only being of the conventional rivetted type.

The heaviest welded section consisted of two side plates, 2 ft. 6 in. deep by 2 in. thick. These were joined by web plates, 1 ft. wide by 1½ thick, by a continuous bead of weld to the side plates. This "H" section was used for the top chord, verticals, and diagonals, while an inverted U section comprised the bottom chord.

The erection of these trusses presented a problm, as they could not be built in position because of the great depth of water. This problem was solved in an ingenious manner.

On the north side of the river, where the water is shallow, a timber falsework was built on temporary wooden piles. It was here that the spans were erected. They were built at approximately the same level as that at which they would finally be set and to the required grade and camber. Suitable towers were erected on two 100 ft. long punts, and when the span had been rivetted the punts were drifted under the span at low tide. With the rise of the tide the span was lifted up on the towers clear of the falsework. The punts were pulled across the river by steam winches to bring the span opposite the piers on which it was to rest. When the tide was high the punts were brought into position so that the span was directly above its bearings. When the tide fell the span gently settled down exactly on its bearings and the punts were floated away. Each of the trusses was 440 ft. long, 35 ft. wide, 70 ft. high, and weighed 640 tons, so the operation was both difficult and spectacular.

Two plate girder spans for each of the piers 4 to 11 were 90 ft. long, 7 ft. 4 in. deep, 16 in. wide, and weighed 17 tons each. They were of normal type, except that welding was used throughout. These girders were delivered by road.

"Closing" the gaps between the piers presented no difficulty, although all early work had to be done by triangulation from the shore and from temporary stagings.

Some interesting items of plant included the two punts and a travelling gantry in the storage yards. The punts, which were 100 x 30 x 9 and 400 tons capacity, were built and launched on the job. One of these punts was equipped with timber shear legs capable of lifting 35 tons at a radius of 30 ft. and having a drift of 60 ft. The other punt was equipped with a complete concrete mixing plant. The gantry crane, which was built, was capable of lifting 30 tons and had a span of 120 ft.

Large quantities of materials, including 1,000 tons of reinforcing steel, supplied by the B.H.P., were used on this highly successful undertaking.

:o:

RECENT GRADUATES.

Bachelor of Science (Engineering), 1944: Alm, Walter Otto—Mechanical. Studying for B.E. Anderson, Colin Charles—Civil. Studying for B.E. Arnold, Donald Clyde—Civil. Lieutenant, R.A.E. Cole, Robert Henry—Electrical. Adelaide Electric Supply Co. Crompton, James Woodhouse—Electrical. Lieutenant, R.A.E. Drew, David Charles Roskilly—Mechanical. Lieutenant, R.A.E. Heard, Lyall Scott—Metallurgy. Hosking, Norman Grantham—Civil. Cockatoo Docks and Engineering Co. James, Robert Jeffery—Metallurgy. British Tube Mills. Jensen, Allan Northbrook—Civil. Lieutenant, R.A.E. Kinnane, Robert Francis—Civil. Studying for B.E. Kleeman, John Richard—Metallurgy. Mt. Lyell Mines. McKechnie, Kenneth Alexander—Civil. Lieutenant, R.A.E. Medlow, David—Metallurgy. Mt. Lyell. Morcom, Robert Richard—Mechanical. Western Oxygen Co. Morgan, John Philip—Mining. Mount Painter. Noble, Andrew Morden—Civil. Lieutenant, R.A.E. Purdam, Irving—Electrical. Adelaide Electric Supply Co. Stapledon, Roger Johnson—Mechanical. Lieutenant, A.I.M.E. Tuck, Gilbert Playford—Electrical Supply Co. Wilson, Colin Leslie—Metallurgy. Lieutenant, R.A.E. Wilson, Gordon Samuel—Metallurgy. Electrolytic Zinc Co.

The Adelaide University Engineering Society

1945 Annual Report

Artium urbertas et scientiae

By BRIAN CLARIDGE, Hon. Sec.

Committee for 1944-5:

President: R. W. Parsons.
Vice-President: D. H. Tyler.
Secretary: P. G. B. Claridge.
Treasurer: L. T. Nicholls.
Second Year Representatives:
J. L. Whittle, P. K. Hosking.
Freshers' Representatives:
L. R. Trott, G. R. Cowley.
Men's Union Representatives:
R. W. Parsons, P. G. B. Claridge, P. K. Hosking.
Union Representatives:
R. W. Parsons, P. G. B. Claridge.

1944 Engineering Ball.

The 1944 Engineering Ball, held on Friday, November 24, was an ambitious and, fortunately, most successful event. An extra floor was put down on the refectory lawn, and supper was served to tables around the cloisters. The F.F.C.F. benefited to the extent of £82/5/- and the A.U.E.S. managed to scrounge 30/-.

Welcome.

Early this year the habitual "welcome" was extended to freshers, and we believe that we can claim success in this function, although it must be admitted that we were caused some frustration when it was discovered that some of our instruments of welcome had been removed by more energetic freshers. However, being engineers, we were able to indulge in same rapid improvisation and the evening continued as per schedule.

The George Murray Hall required some restoration the following day, but we think that it looks more or less as good as it did before.

Meetings.

All the meetings this year were addressed by guest speakers, it being intended to leave student papers for the Engineering Society Debating Club (q.v.) to handle.

At the last meeting of 1944 (the first for the new committee) Mr. Boucher, who had been sometime resident in the Malay States, gave an account of life in these parts just prior to and during the Japanese occupation, and made reference to engineering aspects in this region.

The next meeting (the first for 1945) was in the form of "greetings" (as distinct from "welcome") to freshers by the Dean and his staff. Prof. Robin had some difficulty in recognising the freshers, but when he did he greeted them.

At subsequent meetings the following speakers were heard:

Mr. Ide, from E. & W.S., who gave a talk, illustrated by moving pictures, on the construction of the barrages at the Murray Mouth;

Mr. E. C. Savage, from Penfold's, gave us an insight into wine manufacturing, illustrated with pictures and lubricated with samples;

Mr. C. C. Shinkfield, late R.A.N., who described the development of the degaussing of ships.

Finally, Prof. Sir Douglas Mawson spoke on the possibilities of hydro-electric power in Australasia and its application to the metallurgical and chemical industries.

Interim Dance.

On May 12 we sponsored an end of term dance, this arising out a feeling of the need for another social function. Thus it was, and Wanslea appeal gained £32/6/9.

Seeing is Believing.

Several films have been shown during the year, most at meetings, but some to all and sundry at lunch times. At various meetings we screened:

"Brown Men and Red Sands"; the film showing the spectacular failure of the Tacoma Narrows Bridge; Mr. Ide's barrage pictures, while "Coo-ee, Singapore," illustrated Mr. Boucher's talk. At lunch times we showed several films—one on shipbuilding, another showing the fitting out and final commissioning of a battleship. The next was a film which showed the manufacture and use of cement to-day.

The new 1945-6 committee got away to a flying start this year by showing another film at lunch time, "The Mystery of Steam."

Those who have eyes to see, let them see.

Union Active.

The A.U.E.S. sponsored a Union lunch-hour talk, so enabling the Union to claim another activity, when Dr. Saunders, from the Madras University, spoke on "Student Life and Thought in India." Dr. Saunders was entertained to luncheon, and then addressed a most attentive meeting.

The Articulate Engineer.

Under the capable leadership of Mr. Ron Vogt, the Debating Club has kept its head above water both morally and financially (assets nil, liabilities nil). Several heatedly contested discussions were held at lunch times, and amazing ideas and words of wisdom were forthcoming.

All members are urged to take advantage of the opportunities that this club offers.

Believing that the present Engineering students were illiterate, illegible, and illogical, it was thought by some [apparently literate (?) legible and logical] that a suitable form of English should be included in the Engineering course. This was generally agreed upon, and a letter was sent to the Faculty requesting that something be done, if possible. The Faculty was sympathetic, but could do nothing at the present, in view of the large number of students, except make certain volumes available for Engineering students in the Barr Smith Library. We now browse through Ruskin and Carlyle.

Badges.

An attempt was made to gain permission from the Department of War Organisation of Industries to have metal Society badges manufactured, but the red tape involved was too much for us, and we retreated.

Etherealism.

Certain enthusiasts amongst us have been working all out to revive the sometime defunct Engineers' Glider Club. Past high fliers have been contacted and have shown considerable interest in this proposal and have offered much help and advice.

Recent plans for a primary glider have been obtained from Melbourne, copies of which will be available in the near future.

It is hoped that the necessary money will be raised (borrowed, begged or stolen) before the end of the exams. so that an early start at the construction can be made early in the holidays.

After that, well———

No Laurels.

Unfortunately, we cannot claim distinction in the inter-faculty sporting events, which have been played during the year, although many of our members indulge in some form of sport, and we have several outstanding sportsmen in our midst.

We suffered defeat at the hands of Science in football, losing by 1 goal 3 behinds. The match was keenly contested, and we congratulate our team.

Later Science narrowly defeated our croquet team by one hoop two pegs, or three points, or whatever the correct term is. Our two representatives battled heroically, and the end of this contest was most exciting. We did not know that we possessed such beauties in our midst, for seldom have such buxom lasses graced the refectory lawn.

A BRIEF SURVEY OF THE PLASTIC MATERIALS

By J. H. SHANNON

The use of plastics is not a new art. They were employed in Eastern Asia and India and by the ancient Egyptians in the form of clay for pottery. Shellac, too, was then widely used as a decorative varnish. The technique of lacquering with natural resins was originated in China and developed to its peak as far back as the fourth century in Japan. But it was not until more recent years that a scientific study was made and data collected concerning the many types of plastic materials.

PRODUCTION of celluloid in 1870 marked the birth of the organised plastics industry. Many European scientists then took up the study, and in 1909, Dr. L. H. Backeland published his paper, "The Synthesis, Constitution, and Uses of Bakelite," in which he describes the production of his phenol-formaldehyde resin—a material which paved the way in the field of plastics.

A plastic material is one which may be shaped by moulding. But the bulk of many well known, so called plastic materials in use to-day consist of non-plastic substances, termed fillers—and the "plastics" are sometimes cast and machined or laminated and rolled. However, these are special purpose materials and the greatest single use of plastics is moulding. The two main classes of moulding plastics are the thermo-setting and thermo-plastic. The former, thermo-setting plastic, requires heat and pressure in moulding. Setting hard in the space of a few minutes, these materials do not soften with the further application of heat. Thermo-plastic materials, on the other hand, while softening under heat and pressure, set hard when cooled and reheating softens them.

In the case of thermo-setting materials, a chemical change occurs under the influence of heat. What is known as polymerization takes place; that is, the joining together of single molecules of one or more substances to form a chain-like structure without the formation of a new compound. After polymerization, further heating will not soften the material. Thermo-plastic materials undergo no such chemical hardening and consequently are not such stable compounds.

Plastics may be grouped as natural, chemically modified, and wholly synthetic. Natural plastics are the indigenous resins, damars, copals, bitumen, shellac, casein, and the waxes. In chemically modified materials there are the thermo-plastic cellulose compounds and thermo-setting products, such as vulcanised rubber and ebonite. Finally, the urea- and phenol-formaldehydes, purpural resins, glyptals, and the styrene resins are all purely synthetic.

The properties of a given plastic may vary very widely, according to conditions of moulding, shape of mould, and types of fillers used. Fillers commonly in use are as follows:

Wood-flour and graphite used together in moulded bearings.

Fabrics, such as canvas strips, used in laminated materials, and is difficult to mould.

Asbestos gives heat resistance and moisture resistance; this is also used in conjunction with graphite in bearings.

Mica has an electrical application, as it increases the dialectric strength of the material.

Dyes may be added to give almost any required color.

For moulding, the plastic materials are graded into three grades of "flows," viz., soft flow, medium flow, and stiff flow. In general, soft or easy flow materials are used for deep or intricate mouldings, and the stiff flow for smaller plain mouldings. Flow is varied either by altering proportions of resin and filler, or by changing the curing process during moulding.

There are many different methods of moulding plastic materials, but all seek the same end—that is, speed and ease of operation—for the plastic industry lends itself to mass production very well; and as ever-increasing applications are being found for these materials, new methods of fabrication must be devised.

Some Common Plastics.

Most prominent among the protein plastics is casein. This substance occurs in all mammals' milk. In cows' milk it constitutes from 2%, 4%, and 80% of the protein content. A similar compound is vegetable casein, found in certain legumes, such as the soya bean; but the two are not identical. In milk the casein is found as calcium salts in a colloidally dispersed condition and extraction is achieved by passing the milk several times through a milk separator, adding a little dilute $NaOH$ and again centrifuging. This removes nearly all fat, an essential factor, since fat is highly objectionable in the final product. The casein is precipitated by the addition of dilute acid, washed carefully and dried in vacuum or at low temperatures, as it is adversely affected by heat at about 100 degrees C.

Pure casein is perfectly white and odorless, and is usually prepared as a fine, friable power, which is very hygroscopic. As an industry, the production of casein began in U.S.A. some 40–50 years ago, and has since been developed enormously. Some uses of casein are:

Adhesives, such as glues, cements, and putties.
Size, in the manufacture of paper.
Artificial ivory, celluloid, rubber, and leather.
Linoleum, electric insulators, transparent films and plates and also in paints.

Dry powdered casein, heated to 100 degrees C., softens and becomes quite plastic, being capable of rolling and moulding into any desired shape. When mixed with fillers these plastics dry very quickly. Such fillers as china clay, paper, fine sand, and magnesia are used, according to the properties required; any coloring may be added. Dry casein itself tends to be brittle, but the fillers strengthen the material, and it may be further hardended by adding formaldehyde.

Rubber is another important natural plastic, and it is taken from the exudation sap of certain tropical trees, where it forms a 30% colloidal suspension with water. The plastic mixture of raw rubber and sulphur softens on heating and may be rolled and shaped. Proportions of sulphur vary the hardness of the compound—thus 20–30% sulphur gives hard vulcanite or ebonite and 3–5% sulphur gives a soft rubber. The mechanical properties are changed by the incorporation of mineral powders, such as carbon black and zince oxide; tensile strength up to 10,000 lb. square inch can be obtained. But the material softens at the low temperature of 150 degrees F.

Chlorinated rubber is insoluble in strong acids and alkalis, thus affording a good coating for pipes and concrete.

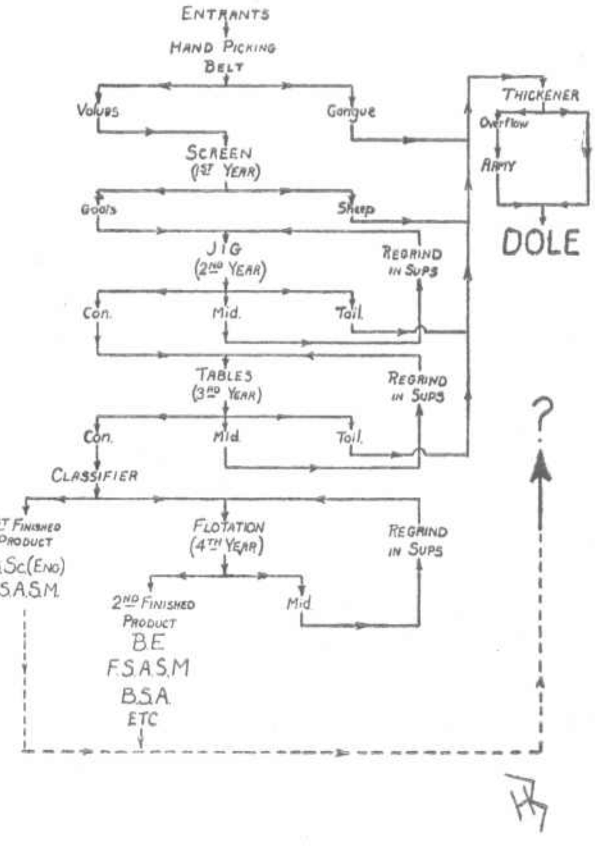
Cellulose acetate is one of the more recent materials which is fast coming into prominence. Purified wood-cellulose is treated with a mixture of the acetic anhydride, acetic acid, and sulphuric acid to give cellulose acetate. To give mouldability and toughness to the compound, plasticizers are added, and different plasticizers combine to give required properties. Formerly cellulose acetate had been used in the manufacture of table tennis balls, washable collars, baby toilet goods, and the like. In recent years, however, manipulation of cellulose acetate sheet has led to the production of such articles as windscreens, turret covers, landing lights, wheel spats, and ammunition chutes for aircraft.

The synthetic laminated plastics find wide application in bearings, rollers, runners, and gears. Synthetic resins, such as phenol-formaldehyde and urea-formaldehyde are used as binders to bond the fabric laminations. The fabric is impregnated with the resin dissolved in methylated spirits, passed through a wringer and oven dried. These sheets are then cut to suitable sizes, placed one upon the other, and hot pressed at about 400 degrees F. to give a thicker uniform slab.

Gears made from this material are quite hard and give long life in service, being used where quiet running is needed. They are often meshed with steel gears, and are used in the automobile industry. In laminated plastic bearings, water, oil, or grease lubrication may be employed, and it has been found that cams made of this material give far better service than metal.

Finally, to give an indication of the scope for plastic materials the following are some recent applications: In medicine and surgery, cellulose acetate sheet is used for surgical masks, instruments made from glass-clear acrylic resins, even optical lenses which fit under the eyelids in direct contact with the eye; extruded tubes in place of rubber tubes for withdrawing body fluids, and dentures made from nitrocellulose. Nylon and rayon hose have found a place in the fabric industries. The former, made from dibasic acids, is bacteria proof, non-inflammable, and may be used as a wool substitute. In the food processing, non-corrosive phenol-formaldehyde resins are increasingly used in canning and preserving; whereas applications in engineering have already been cited. The demands for light, easily fabricated units of all descriptions in aircraft production are now being met largely by the plastic materials. There can be no doubt for the future of such an industry.

ADELAIDE UNIVERSITY ENGINEERING FLOWSHEET
(AS A METALLURGIST SEES IT)



BIRDS

By W. H. OLDHAM

When we have an hour or so to spare from lectures, a pleasant relaxation from studies may be found in bird-watching. The nature-lover, having passed the shanghai stage, when every bird was a target, will find plenty of material to occupy his attention inside and around the University grounds, and although plant life is somewhat restricted, a fair variety of birds may be seen.

HOW many kinds of birds can you recognise? Everyone knows that friendly and useful bird the Wagtail, but we do not often see the Grey Thrush, of about the size of a Blackbird, possessing a powerful bill with which he is reputed occasionally to kill young birds. Such lapses may be excused, however, for he takes first place as a whistler, and his gloriously rich notes may be heard at almost any time of the day. Not so powerful, but very melodious, is the call of the "Greenie," as he moves busily among the leaves and branches, displaying a smart olive-green coat.

Two frequent visitors are the Wattlebird, whose raucous challenge we so often hear, and the Black-faced Cuckoo-shrike, a larger pale grey bird with a strange flute-like call. Although not a true Cuckoo (because it builds a nest of its own), it adopts the undulating flight of the Cuckoo.

The diminutive Yellow-tailed Tit is of interest because of its unusual nest. This structure is most carefully made, and consists of a hollow spherical compartment, the top of which is fashioned into an open cup. One explanation for this double form is that, in the event of a Cuckoo laying an egg in one room, the birds can transfer their family to the other.

The Torrens can always be relied on to support a fair bird population, and as we walk along the bank we will see, besides the dignified Swans, numbers of Teal and the larger Black Duck. In most of their native haunts they have learned the value of wariness, but here, with few human enemies, they may be watched at close range. Also will be seen a light grey duck with a glossy green head and neck. This colorful bird is the Mallard, introduced from Europe.

Trim black Moorhens present a humorous appearance as they strut along the bank, flicking their tails at each step. Even in the water the tail is not still, and one is tempted to wonder whether there is some mechanical linkage between legs and tail. The Moorhen has not yet adopted the retractible undercarriage, for as he flies (when he can be persuaded to fly at all) his legs dangle straight down in a most slovenly fashion, ready, perhaps, to cushion him from the splash which concludes his aerial activities. He is a friendly bird, however, and does not resent our presence, unlike the Shags, which always behave in a sly and furtive manner. Two varieties of Shags are usually to be seen diving for fish, or swimming half submerged at the surface, or afterwards standing with wings outstretched to dry in the sun.

Swallows flit unobtrusively into the picture, and it may be noticed that, while the Common and the White-backed Swallows usually skim low over the water, the Dusky Wood Swallows flutter higher, above the tress, in their search for insects. Several Wood Swallows may sometimes be seen sitting, packed in a tight row, along a thin branch, and they will not fly until we come almost within arm's length.

When passing a clump of rushes on the river bank, we may be surprised by a rich and varied canary-like song. This will be the voice of the Reed Warbler, a small brown migratory |bird, arriving here in August. Its best song, however, is heard at night, like some other birds, notably the Wagtail. The nest, a deep cup of woven reed tops, is slung between several stems in a patch of rushes.

All these and many other birds can be found here within easy walking distance for anyone. When we discard the idea that everything worth seeing is far afield, it is surprising how much has escaped our notice. The excitement of finding a new bird, or some new habit of old familiar ones, is something which cannot be assessed in ordinary values. Bird-watching is a harmless and inexpensive means of occupying our leisure, and it is unlike any ordinary hobby, stimulating us to greater activity, driving us to new fields and providing an interest wherever we may be.

THE EARLY HISTORY OF FLIGHT

By M. E. ANGAS

The history of flight begins, not as most people think, with the Wright brothers and Bleriot, but with the early literature of Greece and Rome. In the fascinating legends and myths of these two countries is to be found the first hint that man had already turned his mind to the conquering of the air.

THE Greek legend of Daedalus and his son Icarus is the first record of flight. During one of those energetic civil wars, the Greeks were so fond of describing, Daedalus and his son Icarus were imprisoned on the island of Crete. Necessity being the mother of invention, Daedalus constructed a pair of wings coated with wax to which he adhered feathers in order to escape. The legend does not relate whether Icarus was chosen to be the test pilot because he was the lighter weight or whether Daedalus followed the designer's principle of "try it on the dog first" lest the flight be a failure. Although warned by Daedalus not to fly too near the sun for fear of the wax melting, Icarus' wings did melt, and he fell to his death in the sea which now bears his name.

The Teutons tell of Wieland, a smith, who angered the King Niduns of Jutland. Feeling liverish, the King ordered the smith to be deprived of the use of his feet. However, Wieland made himself a "strange flying suit of feathers" in which he escaped to his home country.

Early civilisation owes a lot to China, and it is from here that the first report of parachuting came. Some 2,000 years before Christ the Emperor Shun displeased his subjects (it seems even then democracy was known) who imprisoned him in a granary, and having found no torture exquisite enough to suit their taste, decided to fire the granary and burn him alive. Shun found some coolie hats made of reeds in a corner of the threshing room, and making a kind of parachute, jumped to freedom and safety.

The next report of flying comes from English legend, which describes King Bladud as having made feathered wings which he fastened to his shoulders to practice gliding from high places. One fine day he "did'st play the foole" in the year 852 B.C. to fall and break his neck on the Temple of Appolyn in the City of Trinoraitein (where London now stands).

Seventeenth century verse comments thus—

"On high the tempests have much power to wreck,
Then best to bide beneath and surest for the neck."

(Gliding club enthusiasts, please note).

Oliver of Malmesbury, an English monk, was an ardent exponent of flight about 1060. He had, besides wings on his arms, two small ones on his feet. The story goes that, jumping from a tower, he made a glide of a furlong or so, when a gust of wind upset his balance and he crashed to earth, crippling himself for life. To his death he maintained the cause of his accident was the omission of a tail as in the bird.

The Russians had no illusions concerning flight—it was a power given only to magicians and sorcerers. One gentleman had the temerity to make a successful jump from a tower with artificial wings, but unfortunately the Czar witnessed the act and promptly had him beheaded there and then. The Sultan of Constantinople in the year 1178 was more enlightened, for he encouraged the efforts of a Saracen who flew "like a bird in long white robes made stiff with rods, but broke his bones, his weight having more power to drag him down than the wings to sustain him."

The first exponent of aeronautics was the painter Leonardo da Vinci. He spent from 1486 to 1490 devising "flapping wing machines" or ornithopters. Sketches found among his writings show the skeleton framework of these devices. In one arrangement the operator lies face downwards with the framework supporting the wings attached to his shoulders and to his body by a girth. (Safety belts were essential from the first). With legs extended, the feet placed in stirrups and hands clutching handles, the wings were made to flap up and down as a bird's; another sketch shows a similar device—in this machine, however, the operator had a wooden support and his hands were entirely free. Da Vinci later asserted that a motionless wing when struck by a gust of wind received the same support as a beating one.

John Damian, a physician and courtier in the reign of James IV. of Scotland, about 1508, was the most optimistic of the early fliers. He distinguished himself by leaping from the tower of Sterling Castle with the idea of flying to France or Holy(!) by means of wings made of hen's feathers. Alas, his landing field was not La Belle France but a dung heap by the kitchen quarters of the Castle, where he broke his thigh. Some jester remarked that had he used eagles' feathers all might have been well, for hens have a great affinity for dung heaps. The exact variety of birds' feathers seems to have been the subject for many a heated debate, and the combinations evolved innumerable and elaborate.

In A.D. 1678 the first French flight recorded was made by a locksmith, Besnier. It is said that he took off from a garret window and actually soared over a roof before landing in the street below. Besnier did not have feathered wings but a system of plane surfaces hinged to a central boom held in his hands while his feet operated the rear surfaces or flaps. Later, in 1742, the Marquis de Bacqueville, an enterprising member of the French aristocracy, tried to cross the Seine from the Rue de St. Pierre to the Tuileries Gardens by means of paddle shaped wings attached to his arms and legs; history relates that a barge picked him out of the Seine with both legs broken.

Bacon, most famous for his "Essays," conceived the idea of a large balloon filled with "ethereal air" which would float in the air. Later, in 1670, Lana investigated this, and his method became the fundamental principle of the balloon. He proposed to use an aerial boat fitted with four large globes, made of thin copper sheet, from which all air had been exhausted. The vacuum within the globes was to give the ascending force and the motive power was to be provided by a central wind sail. The difficulties of constructing the globes proved an unsurmountable obstacle and the idea was abandoned. In 1783 Joseph Montgolfier created the hot air balloon and from then on the rivalry between the gas method of raising man and the mechanical method of flight became intense. The first occasion of a balloon used for military purposes was at the Battle of Fleurus, June, 1794; again a balloon was used in effecting the famous escape of Gambetta during the siege of Paris in 1870.

From 1800 to 1862 three Englishmen were the most prominent of the scientists who were studying aeronautics. Sir George Cayley designed numerous flying machines, one of which was a glider designed to reach a maximum velocity of 13.6 m.p.h. and, in which, to "avoid the inconvenient weight of a car and wheels" he thought to support a man by "substantial loops, well padded." A further rough sketch gives the outline of a machine in which beating wings are operated for initial tractive force, and fixed wings for sustentation. The wheels of this machine have made history. Cayley described them in his notebook, dated the 9th March, 1808, and called them "tension wheels." They consisted of a rim supported about a hub by cordage under tension. Wire wheels on the same principle are still used today.

James Stringfellow, one of the founders of the Aeronautical Society, in 1842 commenced, with the help of Cayley's writings, to devise a practical form of the aeroplane, and in 1848 he had constructed a large steam driven model, but sustained flight was never accomplished. Phillips, in 1862, gave particular attention to wing construction and was one of the pioneers of aerodynamics.

After this the development of the aeroplane became rapid. In 1890 Ader, a Frenchman, designed a 'plane of wingspan 44 ft., area of 570 square ft., and weight of 580 lbs. Two steam engines, each of 20 horse power, were made to drive two four-bladed propellers. Unfortunately, this plane came to grief when about to have her trial flight. By this time the problem of flight was being tackled from the point of view of control, stability and aerodynamic efficiency, and hence the perfection of the glider. Langley and Chanute worked in America, Lilienthal in Germany, Pilcher and Maxim in England. Lilienthal's glider took the form of large rigid planes in the shape of a bird's wings, and a tail having a horizontal and vertical fin. Guiding and balancing was performed by the swinging of the operator's body and legs. Chanute advocated the principle in which equilibrium was obtained by altering the relation of the centre of pressure on the wing to the centre of gravity of the body as a bird was thought to do by a fore and aft movement of its wing. Later Chanute disagreed with Lilienthal's birdlike form of glider, maintaining that movable wingtips were necessary to correct the balance, and that there should be no weight suspended below the planes, the operator spreading himself flat on the planes. He then built a biplane glider with warping wing-ends, meeting with considerable success.

In England Pilcher had built a glider approaching the aeroplane form and towed it as a kite, but soon afterwards met his death. Sir Hiram Maxim constructed in 1888 a large machine with a wing span of 105 ft., an area of 4,000 square feet and a weight of 8,000 lbs. A steam engine of 350 horse power drove twin propellers. Like so many other steam driven planes, this machine broke away when ready for launching and smashed itself to bits.

1896 brought forth Langley, who after intensive research on wing forms, produced a successful flying model of total weight 26 lbs.!! It was driven by a 1 horsepower steam engine, and reached a height of 100 ft., covering two-thirds of a mile in one and a half minutes—a phenomenal effort.

Following on the finding of the earlier experimenters the Wright brothers gained considerable success with gliders in 1900. The design followed Chanute's form with movable surfaces, and a slight dibedral given to the wing. The longest glide made was about 315 feet at the relative speed of 25 m.p.h. in a 13 m.p.h. wind, with a glider of 22 ft. span, 7 ft. chord and 290 sq. feet area. The weight was 98 lbs. After this the Wright brothers turned their attention to the mechanically propelled machine, and on December 17, 1903, the Wright biplane left the ground, remaining in the air twelve seconds, and then flying a distance of 825 ft. in 59 seconds. This was the first sustained flight of the mechanically driven man-carrying aeroplane, and was accomplished with a machine of 40 ft. span and 6 ft. breadth. The motor developed from 15 to 20 horsepower, and weighed 40 lbs., the total weight of the machine being 925 lbs.—a far cry from our 'planes of 20,000 lbs. or more, and their engines of 1,300 lbs., developing over 2,000 horsepower.

From here on it was a short step to long, sustained flight. Colonel S. F. Cody flew 40 miles in 1909, and on July 25 of the same year Bleriot flew the English Channel. In 1910 Corbinez gained the admiration of the world by crossing the Andes at a height of 20,000 feet, and Monsieur Pegoud astounded the incredulous public looping the loop, introducing the science of aerobatics.

The Great War of 1914-18 finalised the question of the utility of aircraft and design made tremendous strides which have not stopped yet, nor seem likely to. However, we must not forget that we owe everything we know of man's power to fly to those early experimenters who risked ridicule, defamation and death in order that we might rise to conquer yet another realm of the universe—the air.

VISCOSITY DETERMINATIONS OF OPAQUE FLUIDS

By R. W. PARSONS

With the development of the art of lubrication during the past twenty years, viscosity has come to play an important role in the work of the engineer. The suitability of an oil for certain purposes is often determined by its viscosity at the working temperature—if too viscous, there may be considerable energy losses at high speed, while if not sufficiently viscous, rapid wear of the engaging surfaces takes place.

But viscosity determinations are not confined to lubricants alone. Some substances—e.g., mustard gas, which is prepared as a rather heavy, viscous liquid—deteriorate on standing, or on exposure to light, and when this happens the viscosity alters appreciably. Hence if we can compare the viscosity of a sample of the fluid with that of a standard sample, we can decide whether or not the former has deteriorated.

In this article we are confined to fairly viscous liquids—e.g., glycerin, or the oils used for lubricating the high speed parts of automobile engines. There are several methods available for measuring or comparing the viscosities of such liquids, but one of the simplest uses a fact discovered by Stokes. If a small sphere in a viscous medium is acted upon by a constant force, it does not accelerate indefinitely but reaches a certain limiting velocity. The common case is that of a sphere falling through a fluid under the action of its own weight. Under these conditions, the limiting velocity, or the velocity of sedimentation, as it is often called, is given by—

$$V = \frac{2\ r^2 g\ (d_0 - d_1)}{9\ n\ r}$$

Where ~~n~~ is the radius of the sphere,

g = the gravitational acceleration

n = the coefficient of viscosity of the fluid.

d_1 = the density of the fluid.

d_0 = the density of the sphere.

This formula applies only to the ideal case when

(i) the velocity of the sphere is very small

& (ii) the volume of the liquid used is infinite.

The velocity is kept small by using small spheres. Those most readily obtainable are small steel balls of diameter $\frac{1}{8}$ in. and density, approximately 7.6. These are quite suitable for use with fairly viscous liquids, giving velocities of the order of 1 cm. per second. It is obviously impracticable to use a very large volume of fluid, but if we use a small volume, then the walls of the containing vessel affect the velocity of sedimentation. Ladenburg considered a small sphere falling along the axis of a cylinder containing liquid, and, after allowing for the disturbing effects of the sides of the cylinder he arrived at the formula:

$$V = \frac{2\ r^2 g\ (d_0 - d_1)\ x K}{9\ n}$$

Where K is a constant depending on the dimensions of the ball and the cylinder, but not depending on the viscosity n.

Hence if we can determine the velocity with which a small metal sphere falls through a cylinder containing the liquid under consideration, we can at once determine the liquid's viscosity. The method can be used to make absolute determinations, or to compare the viscosity of a sample with that of a standard oil. Clearly, if V_1 and V_2 are the rates of fall of the steel ball in the two liquids respectively, then

$$\frac{n_1}{n_2} = \frac{(d_0 - d_1)}{(d_0 - d_2)}\ \frac{V_2}{V_1}$$

or if we simply measure the time taken by the sphere to fall a distance x,

$$V_1 = \frac{x_1}{t_1}$$

and hence

$$V_2 = \frac{x_2}{t_2}$$

$$n_1 = n_2 \frac{(d_0 - d_1)}{(d_0 - d_2)} \cdot \frac{t_1}{t_2}$$

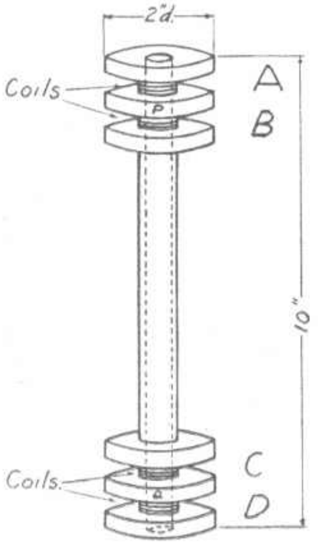
Knowing all the quantities on the right-hand side, we can easily find n_1.

Determinations with transparent fluids are carried out by allowing the sphere to fall through the liquid which is contained in a glass cylinder, and the time of fall between two marks P and Q on the glass is measured by an observer with a stopwatch. This is not difficult, as the velocity of sedimentation is usually about 1 cm. per second. However, this method obviously is not possible for opaque fluids such as oils, and hence we must devise a method of determining when the sphere is passing P and when it is passing Q, when the sphere itself is invisible.

Use of Inductive Coils

Instead of a glass cylinder, we use a former of bakelite or some other plastic material, on which are wound four equal coils of fine wire as illustrated in fig. (i). The dimensions given are only approximate, but serve to illustrate the size of the apparatus.

Coils A and C are connected in series, and so also are B and D. The system is then connected to an alternating current bridge as shown in fig. (ii).



The Alternating Current Bridge

The Wagner earth is simply a device for bringing points X and Y to earth potential and hence reducing any errors caused by capacitances to earth. Since it is not essential to a consideration of the theory of the apparatus, it may be neglected, and in the following discussion we will consider only the equivalent circuit diagram—fig. (iii).

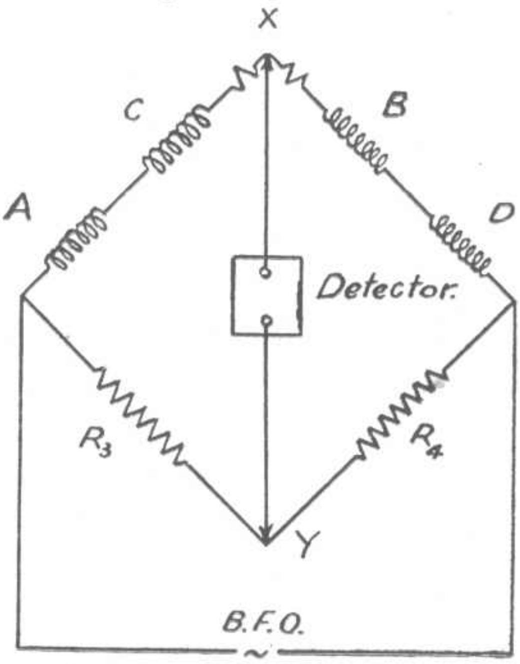


Fig. 3.

Alternating voltages can be resolved into two components—one in phase with the current, and the other ~~180~~° 90 out of phase. In an A.C. bridge, we must balance out both components, and hence two adjustments are necessary. The in phase component is balanced out by varying X, and the quadrature by varying Y. Balance is easily detected using a Cathode Ray Oscillograph coupled to an amplifier.

The first stage consists in balancing the bridge

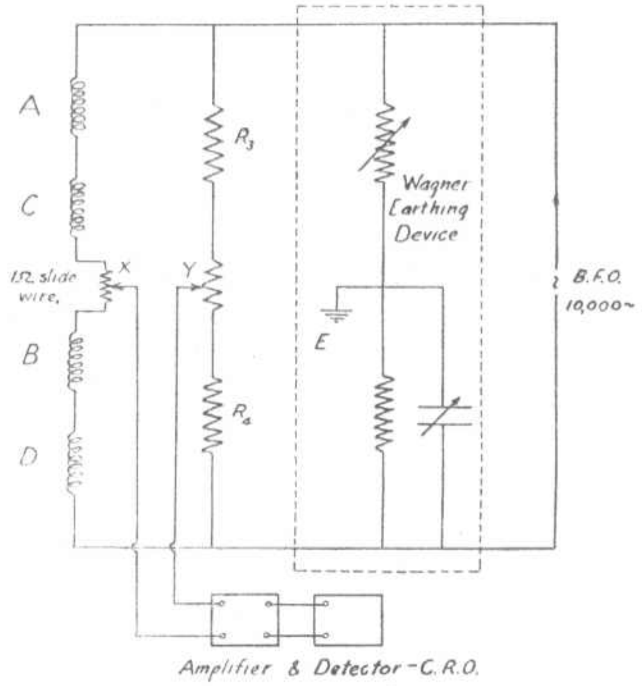
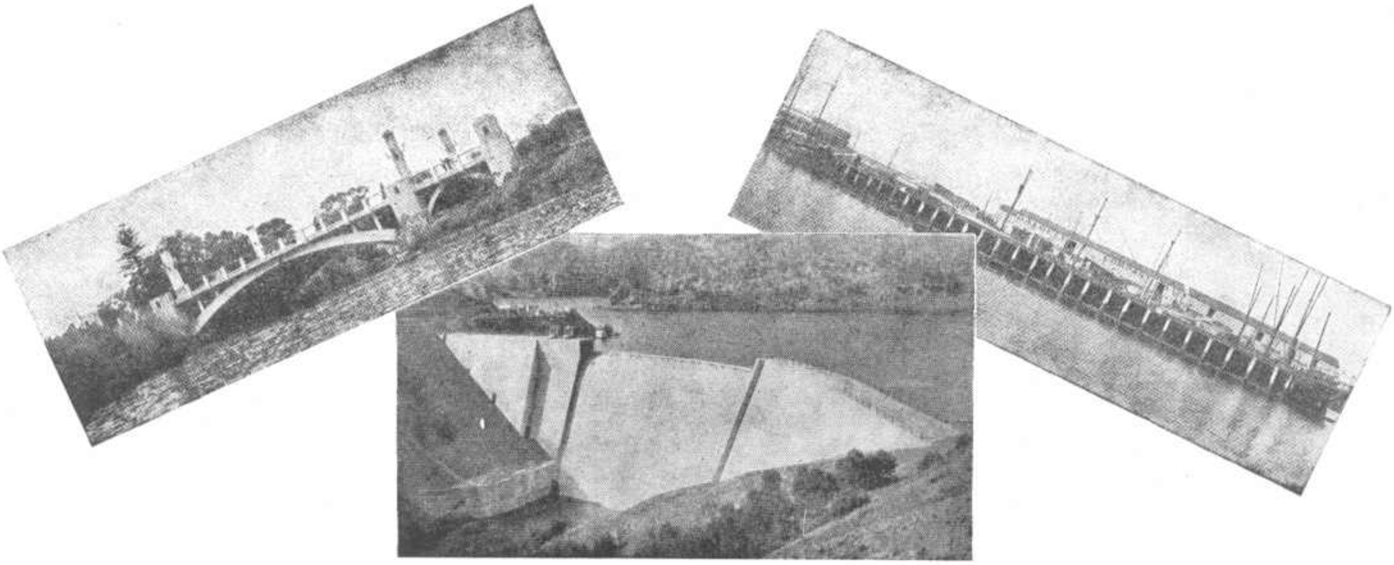
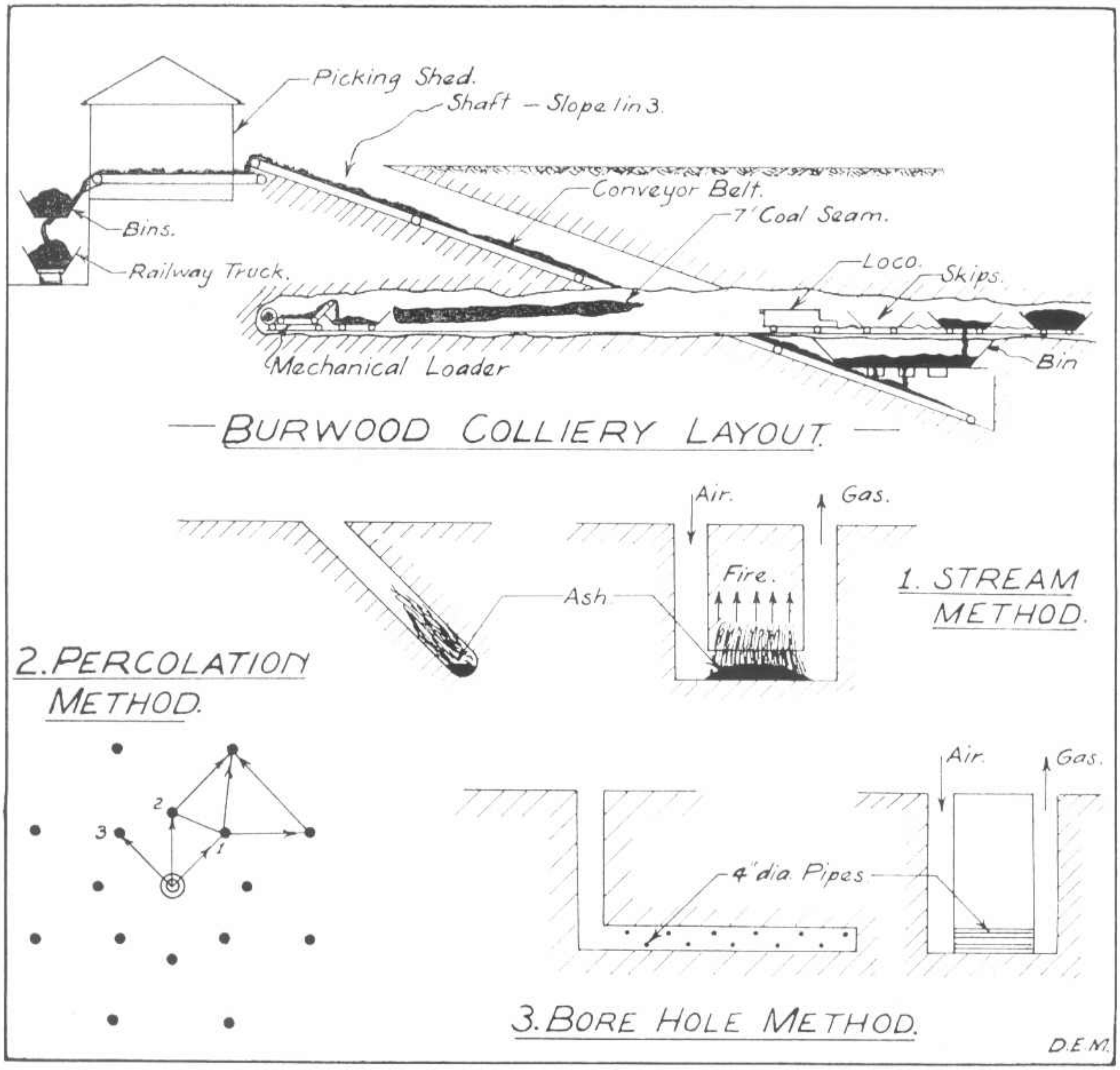


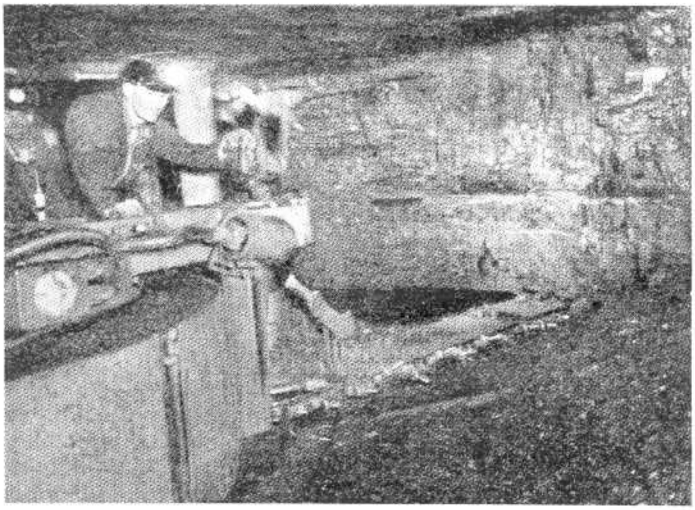
Fig. 2.



WE wish to take this opportunity of thanking those firms who have advertised in the magazine. Without their co-operation the production of this magazine would have been impossible, and we hope they will favour us with their business next year. We would also like to thank E. J. McAlister & Co. who printed and published the magazine, and Mr. E. O. Newson, our advertising agent.

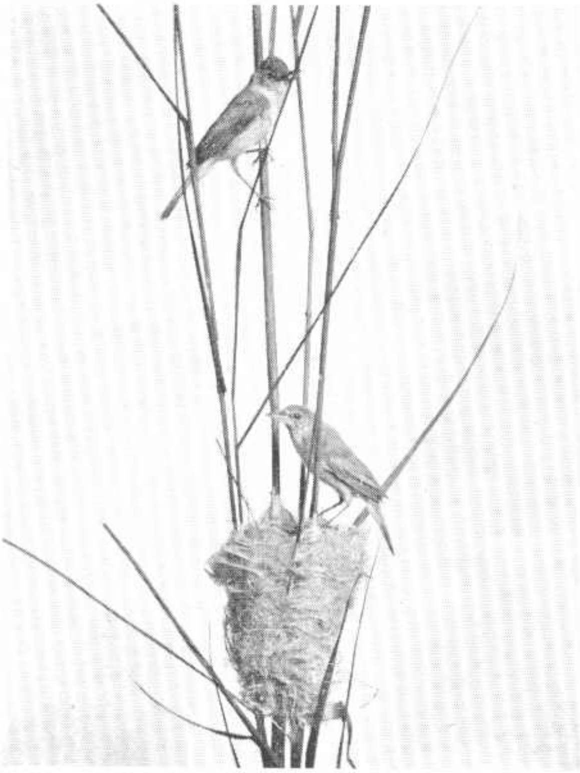


Above: Lay out at 300 ft. level, Burwood Colliery, N.S.W.
Below: Three methods of underground gasification.

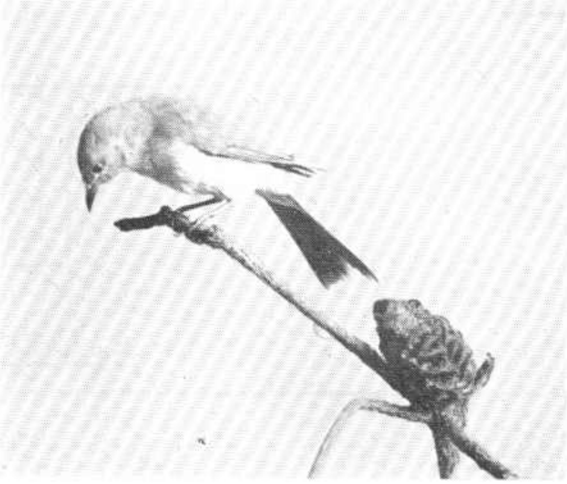


COAL CUTTER *undercutting the seam at Burwood.*

RED WATTLEBIRD.

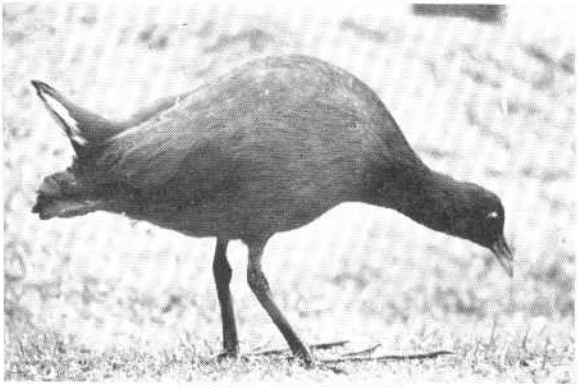


REED WARBLERS.



GREENIE.

GREY THRUSH.



DUSKY MOORHEN.

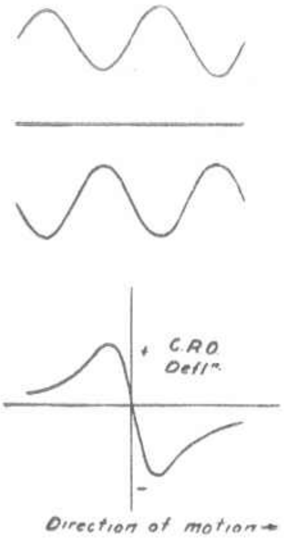
when no iron or other magnetic material is in the vicinity of the coils.

The small steel sphere is now released, and falls slowly down the axis of the coils. When it is in coil A, the inductance of A is increased, and hence the balance of the bridge is upset. A potential difference therefore exists between X and Y, and this is registered on the C.R.O. as a sinusoidal wave form—fig. (iv).

When the sphere is mid way between A and B, at the point P, it affects the inductance of both coils equally, and since these coils are in adjacent arms of the bridge, no out of balance potential will exist and the deflection of the C.R.O. will fall to the straight line of fig. v.

As the sphere passes on into coil B, an out of balance potential will again be set up between X and Y, due to the increase in induction of B.

However, this potential will be 180° out of phase with that of fig. iv., and hence the deflection of the C.R.O. will be as shown in fig. vi. Thus as the ball passes from one coil to the next, the deflection of the C.R.O. will change from a positive maximum through zero to a negative maximum as illustrated in fig. vii.



Figs. (iv), (v), (vi) and (vii)

Clearly, as the ball is passing through P, the deflection is passing through zero.

The ball continues moving along the axis of the cylinder, and when it reaches the lower end, exactly the same cycle of operations occurs, the C.R.O. deflection passing through zero as the sphere passes through R.

The problem of finding the time of fall from P to Q has now been solved. We simply measure the time interval between the C.R.O. deflection passing through zero, corresponding to the sphere at P, and the deflection passing through zero when the sphere is at Q. This can be done with the aid of a stop-watch.

Measuring the Distance P Q

If the apparatus is to be used for absolute determinations, we must know PQ, in order to calculate the velocity of falling. This is easily done by suspending the sphere on a fine thread and lowering through the cylinder. Marks are made on the thread when the C.R.O. deflection is zero, and the distance between the two marks equals the distance PQ. Although this may seem very crude, an error of $\frac{1}{2}$ m.m. will only cause a relative error of $\frac{1}{2}$ in 250 or 0.2% which is usually negligible.

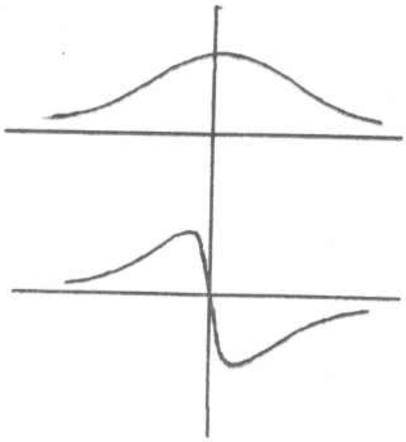


Fig. (viii)

It is, however, generally sufficient to compare the viscosity of the specimen with that of a standard sample, and in this case the distance PQ need not be known.

Advantage of Using Four Coils

A somewhat similar method has been used, with two coils instead of four. In this case the deflection passes through a maximum value as the sphere passes through the point P, which will now be in the centre of the top coil. However, it is much more difficult to determine exactly when the deflection is a maximum than when it is zero, and hence the nul method is very much preferable. See fig. (viii).

Using this apparatus we can find viscosities very quickly and accurately, and hence the method may find extensive application in the future development of the art of lubrication.

Modern Coal Mining Methods

By P. BROKENSHA and L. T. NICHOLLS

Coal is indispensable to modern civilisation and man has long studied the best methods of mining it. This article deals with the three main methods. Firstly as an example of a modern underground mine is a brief account of Burwood Colliery, N.S.W. Secondly there is a short account of modern methods of open cut mining with special reference to Leigh Creek and Yallourn. Thirdly we have a glimpse of the latest method of "mining," underground gasification.

1. Burwood Colliery

The only large deposit of bituminous coal in Australia is found in N.S.W. near Sydney. The deposit takes the form of a basin whose centre is Sydney, with a radius of about 100 miles. This coal basin comes near the surface around Newcastle in the north, Lithgow in the west, and Wollongong in the south, and it is in these places that most of the mines are situated. The Northern Maitland and Newcastle fields are the most developed and supply the bulk of Australia's bituminous coal.

The Burwood Colliery, which is seven miles from Newcastle, has two seams of high grade bituminous coal at 320 feet and 600 feet.

The deeper seam is still being mined by the age old methods involving much hand labor and the use of pit ponies. The other seam, however, is mined entirely by mechanical means, and is perhaps the most modern coal mine in Australia.

The first remarkable feature is that the main shaft is not vertical, but slopes at about 16 degrees. The car to transport men to the seam runs on rails down this incline, and is hauled by a winch and cable. On arrival at the seam level the first thing one notices is the size and strength of the main drive which is framed with heavy I sections and completely bricked in. It is all painted white to improve the lighting, and so that any accumulation of coal dust on beams, etc., could be noticed. If this dust is in sufficient quantities and fine enough it forms a violent explosive mixture. Along the top of all the beams fine rock dust is spread so that if an explosion does occur this will be shaken down and will blanket the coal dust.

The coal seam itself is only about seven feet deep and a thin layer of rock runs through the middle of it. The seam is worked by the pillar and room method. That is, tunnels are driven at right angles to each other, forming in plan what looks like a cross-word puzzle. The coal is removed for a width of about 12 feet along the tunnels, and the centre of each rectangle so formed is left to support the earth above. These pillars are about 80 ft. by 40 ft., so a large percentage of the coal is left. No effort is being made at present to mine these pillars, as it is an extremely difficult undertaking requiring the miners to work back from the outskirts of the mine collapsing the tunnels behind them as they go. In some places at Burwood the miners are working three miles out under the sea.

The actual winning and transporting of the coal is extremely efficient. The coal flows in an almost unbroken stream right from the working face to the railway trucks. All haulage underground is by means of 10-ton electric locomotives, which are powered by 88 batteries and develop 32 h.p. The batteries, which work the motors at 125 volts have to be recharged each night for the next day's shift.

The first operation consists of cutting out the thin layer of rock in the seam. This is done by a mechanical coal cutter, which is hauled by a loco. to the face. When the seam has been undercut to a depth of four feet the shot holes are bored by electric rotary drills. The charges are inserted and the section blasted. A mechanical loader is then brought up to the face and this machine loads the fallen coal into the waiting skips in a matter of minutes. The only extra manual work required is that of putting a pick through the largest lumps. As the shaft progresses the first men along are the timberers, who support the roof with massive 12 by 12's and larger. They also lay the track up to the new face and the cycle of operations is repeated.

Meanwhile the full skips of coal are hauled back to the discharging station. Here an automatic trip gear between the rails opens the bottom of the skips and the coal discharges straight to a large reinforced concrete bin. From this bin there is an automatic feed on to a rubber conveyor belt, which takes the coal straight up the inclined shaft to the surface. Here the belt passes through a picking shed, where boys have the monotonous job of picking off bits of rock, fossils, etc., From here the belt feeds large storage bins, which are placed over the railway tracks to facilitate loading. There is a direct railway line to the B.H.P. steel works, where the coal is converted to coke, which is an essential blast furnace ingredient.

This mechanised mine is a great step forward from the old primitive methods in which men and boys labored many hours per day in narrow spaces to produce a few tons of coal. It is not unreasonable to suppose that better and more efficient mining methods will be introduced.

The underground gasification of coal has opened up startling possibilities. Soon the sweating miner may be replaced by a white-coated engineer at the surface who has merely to touch a button and the vast store of energy which the sun created millions of years ago will flow out ready to be harnessed to the needs of man.

2. Open Cut Coal Mining at Leigh Creek and Yallourn

In mining more than in any other branch of engineering or science, cost is the ruling factor. This may not apply strictly in war-time, but in peacetime the first and last consideration is £ s. d. In other branches of engineering a job may be undertaken for its convenience, as with many of our railways and water schemes, but except in national emergency convenience does not enter into the question in mining. This is meant to be a paper on methods of mining, but it is interesting to see why low-grade coal at Yallourn should be mined to the extent of 20,000 tons a day while Leigh Creek is having such a struggle to come into production.

Firstly as regards quality. Yallourn coal is a Miocine deposit ,that is it is very young as coals go. It has a calorific value of only 6,000 B.Th.U. per lb., and from the main cut contains 65 per cent. moisture. Leigh Creek coal is Triassic in age, and is well on the way to becoming a true bituminous coal. It has a calorific value of about 8,000, which compared with a Newcastle coal which might go 13,000 B.Th.U. lb. is very favorable. Leigh Creek coal, however, powders badly when transported, and must be briquetted if there is not to be a great deal of loss. This immediately puts up the cost of the coal and the percentage cost is high compared with mining costs. Further, the briquetted coal cannot stand a wetting, which causes it to crumble. Tests conducted using tar as a binder, as is done in Germany with their brown coals, have been unsatisfactory and would further increase the cost. It is interesting to note that of an overall cost of 30/- per ton to produce briquettes at Yallourn, 22/- is spent on drying and briquetting, drying being a necessary preliminary, and only 8/- a ton is spent on mining.

Mining at Leigh Creek was first attempted some years ago by underground methods, but the expense was too great. Recently open cut work has been started at the northern end of the main deposit, where the coal outcrops practically at the surface. The seam dips away at about 40 degrees and the proportion of overburden to coal will increase. However, in America 20 ft. of overburden have been successfully removed for 1 ft. of coal, which is a much higher ratio than is likely to obtain at Leigh Creek for some time. At present two $1\frac{1}{2}$ yard draglines are used. The draglines are essentially a diesel driven tractor to which is attached a long boom to which the scoop is attached. The scoop as swung out as far as possible by the operator and then is dragged back towards the machine, where it is raised and dumped in the motor trucks. These leave the pit on a graded track round its periphery and take the coal to the loading station.

At Yallourn the work is on a far bigger scale. The average depth of overburden is only 33 ft., and since this is friable sandy material it is removed directly with small 2 yard draglines. The coal bed is about 250 ft. deep and is worked in two benches of 90 ft. and two of 40 ft. Because of the quantities produced, very large machinery is economical. There are altogether 2,500 ft. of workable face and land dredgers operate, one on each of the large benches. An endless chain of buckets scrape the soft coal upward, discharging it beneath the body of the dredge. A 10 cubic yard power shovel is used on the smaller bench. This moves on lines of its own and digs upwards above the level, whereas the dragline works best below the level on which it stands. Overburden disposal becomes a problem in a big venture like this and at present is being dumped at the bottom of the pit. This lessens fire risk, which is serious in summer time, and is also a handy spot for the waste and helps to fill the hole, which is 300 ft. deep in the centre. The coal is delivered directly to the power house, where all that is not used for briquetting is burnt immediately and used to generate electrical power, which is the cheapest way of transporting the energy in the coal.

Coal will become increasingly more valuable as world stocks are depleted. The day will come, if it has not already, when Leigh Creek coal can be successfully mined, but the problems facing it, in particular the water problem, are rather great. The rainfall in the district is only about the 5 inch mark.

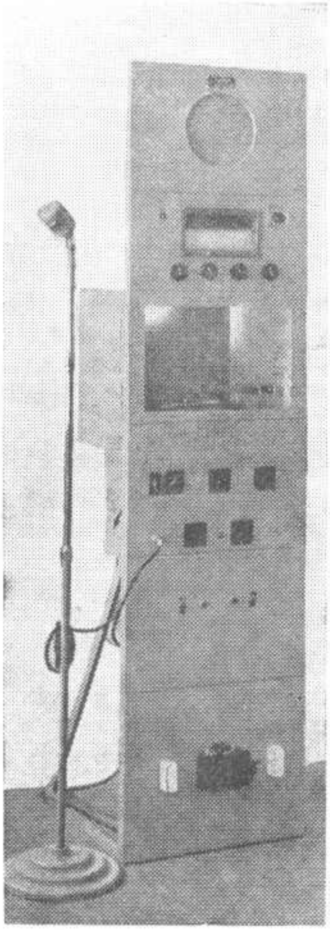
Yallourn coal is steam dried for briquetting but burnt directly in the power station. Leigh Creek coal contains only about 16 per cent. of moisture and is suitable for furnaces in its raw state, but boilers would need large quantities of good water.

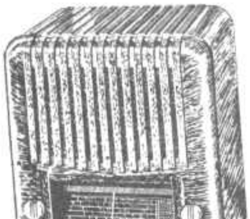
The chief hope for the future of Leigh Creek coal is that sufficient demand is made for coal to enable it to be mined on a large scale and so reduce the cost of mining per unit. It may then be transported further south, to say, Pt. Augusta, where more water is available and there burnt to supply power to the settled areas.

3. Underground Gasification

Schemes for burning coal underground were patented in England as far back as 1909, but Russia is the only country which has carried on the work to any large extent. There are three main methods in use, all of which depend on burning the coal underground in a stream of air, which may be enriched with oxygen, with or without steam under conditions to give carbon monoxide.

1. Steam Method. This is used where the coal seam dips steeply. Two galleries, which may be 60 yards long and 100 yards apart, follow the dip of the seam and are joined at their lower end by a





horizontal gallery. A fire is lighted in this bottom gallery and is supplied with air through one shaft, while the gases are drawn up the other. The coal gradually burns upwards along the seam, while all ash and debris fall down below the fire zone.

2. Percolation Method. This is used for horizontal seams. All underground labor is abolished. Surface borings are made in concentric rings of 30 to 40 yards radius, or in a rectangular pattern. At the bottom of the central borehole the coal is fired and combustion maintained by air or oxygen supplied through a central annular pipe. Initially the gas passes up the centre annulus, but as the coal burns and cracks form in the coal it is possible to pass the gases through the seam to one of the boreholes in the first concentric ring, which has also been fired. When the coal between these two bores has been gasified hole number 2 is closed and the next hole in the first ring is brought into use. In this manner it is claimed the whole seam can be worked out.

3. Borehole Producer Method. Two parallel galleries are driven through the seam about 100 yards apart and these are joined at five yard intervals by boreholes 4 inches in diameter. These holes are sealed until required, and each is fired in turn by an electric device fired from the surface. As in the first method air possibly enriched with oxygen is supplied down one shaft and gas taken up the other.

By combining all three methods and using more oxygen production in Russia has jumped enormously. One man can now produce the equivalent of 100 tons of coal in one month.

However, gasification is only applicable providing (a) The coal is of right type and (b) The energy can be converted at the pit top or near it.

THE ETHICS OF SCROUNGING

By "THE SCROUNGING SAPPER"

Scrounging ethical? Certainly. This is a rigorous if unwritten code to which all but the veriest amateurs adhere. Permit me, as an ex-member of the "Thieving Third," to lay down the law. This was our proud title, in a division which our good friend and mentor, Lord Haw-Haw, dubbed "Ali Baba Morshead and his Twenty Thousand Thieves."

Necessity produced the common or garden variety of scrounging. If all the wise and eminent men who through the ages have praised the engineers' virtues of resourcefulness and initiative were to file through our camp, I suspect they would leave much useful equipment behind them. If the Air Force or the Springboks had more and better trucks, was it not advancing the war effort to share such equipment more equitably? But the artist would not be content with getting the truck; he must also swap the body with another truck, add or remove a spare tyre, change number-plates, camouflage it anew, name it after some fair though distant damsel, and drive it back through the original owner's camp to test his workmanship. Truly, there is no more solid satisfaction than that of a job thoroughly and honestly done.

But the fine art is not limited to the sordid necessities of existence. There was a piano, one only, in Tobruk. How would it be to get that for the mob? Think of the morale of the troops. Right—all jump into the old Ity Diesel truck; somebody get a sergeant's tunic, if you can find a clean one; drive boldly to the Y.M.C.A. and ask the bloke in charge to help you lift the piano aboard. "Major —— told us to take it to the naval officers' mess." Then drive like hell before anyone wakes up to you. Simple, isn't it?

Enemy equipment is fair game for all and sundry. We were often grateful for Italian trucks and fuel, for the "bush artillery" of Tobruk, and the cases of spa water, which gave such a smooth lather for shaving. The local Wogs (worthy Oriental gentlemen) came into the same category, although with them it was a case of give-and-take. If the elusive Wog were reported to have folded our tents and departed in the night, yet it was also rumored that the troops had borrowed Wog taxis for a few weeks at a time. In Beirut methinks the innocent civilians were introduced to "two up," where the pennies faithfully turned up "heads," despite the law of averages and the top hat curve.

Needless to say, your own mates could safely leave great rolls of notes lying about the camp. Their property is sacred. But other units? Suppose you are short of tools—some low, thieving cow has swiped your beaut. new set of socket spanners. Some blokes would come at anything, wouldn't

they? But why brave the ire of the quarter-master sergeant to beg for a new set? Better, far better, to invoke the assistance of Allah and go out on the scrounge, and with any luck you may return with two full tool-kits under each arm and a crescent-spanner between your clenched teeth.

How about our allies? The Free Conglomerates in the Mouldy East seemed to struggle along on the Tommies' left-overs. So it was considered unsporting to have a go at them. But when we met our buddies it was on again. But I recall the chap who was giving a Yank an earful about the Jap flag which he captured in mortal combat, when the Yank asked if he could translate the squiggles on it. No, he could not. So the Yank called his buddy, who "was an interpreter"; and he translated the music to mean:

"Rice—keep in a dry place."

The disgusted Aussie gave him the darned thing. Only later did he begin to wonder.

But only scrounging for the pure love of the game can explain why some sappers in the desert were so fascinated by a noble four-seater wooden structure reposing in solitary grandeur out in the middle of The Blue. True, there were sundry fellows inhabiting divers "doovers" thereabouts, but that did not deter the envious engineers. A quick heave, all together—up in the truck with it; and back to camp in triumph to set it up for "O.R.s Only."

Three New Applications for Explosives in Civil Engineering

By JAMES C. ROUNSEVELL

Recently developed have been new methods of working in soil using explosives as a source of energy instead of drop hammers and other heavy mechanical contrivances.

An explosion is a source of energy which is hard to control and the charges used for particular jobs must be decided by the method of trial and error, but I have endeavored to give figures that have been used, and these will give a guide to the quantities necessary.

The advantage of explosives is, of course, that heavy equipment is not needed. Also the process of "rigging up," which is such a large factor in pile driving for instance, is eliminated. The method has proved its worth in isolated locations, where the cost of transport of equipment is high; and in small or isolated jobs where the cost of "rigging-up" is not vindicated.

Three examples have been selected and will be treated briefly below. They are—

(i) pile driving;
(ii) undisturbed soil sampling;
(iii) soil consolidation.

Pile Driving

The site is driven by a charge placed in a special cap on the top of pile.

The cap for a 12 in. diameter pile is shown in figure I. There is a steel disc, 18 in. diameter and 1½ in. thick, and on the bottom of this is welded a steel ring 4 in. deep and 12 in. inside diameter. The top of the disc carries a tube of cardboard or Sisalkraft, 18 in. diameter and 8 in. high. Into this tube is placed the explosive [50/50 ammonal and sand (—80) sieve]. The charge is 2 lb. of ammonal and an equal volume of sand. This mixture takes up just over 1 in. of the tube. Into this is placed the primer, detonator, and safety fuse or primacord for firing. The whole is then covered with a waterproof disc and the tube filled to the top with tamping (sand and slag).

The charge is now ready for firing. The pile is penetrated 10 in. per charge as an average figure.

An important factor is protecting the top of the pile against damage. This seems influenced most by the depth of the ring welded to the disc. This has been given as 4 in. for a 12 in. pile, but should be increased for larger diameters. With this precaution the top of pile suffers no damage.

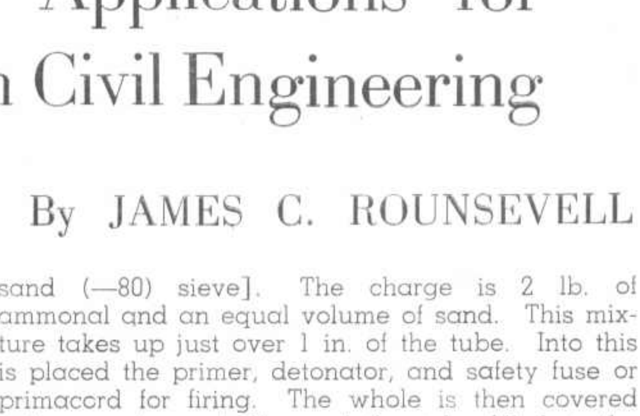


Fig. 1.

The major application of this method has been

to give a final set to piles sunk by jitting. It has also been used for piles in isolated locations.

Since the forces involved are rather obscure, there appears no way of computing the bearing value of a pile driven in this way. Some rough idea may be got from correlating the penetration per charge with the bearing value, using a drop hammer and ordinary pile-driving formulae as a standard, but there is no mention of this having been done.

Undisturbed Soil Sampler.

The spoon for undisturbed soil sampling has been driven very successfully with an explosive. An immediate objection appears to be the damage that the "shooting" would cause the soil sample so far as recovering an "undisturbed" sampler is concerned. Actually, rather surprisingly, the reverse is the case. It has been found with this very rapid penetration of the soil by the spoon the sample is disturbed less than with conventional ramming or pushing methods. The soil is not compressed, neither are the soil layers bent nor the moisture content altered. With the 10 ft. samples sometimes taken there is a certain amount of compression in the lower part of the sample, due to the effect of wall ~~pillars~~ and other factors, but this inevitably occurs in any long sample.

friction

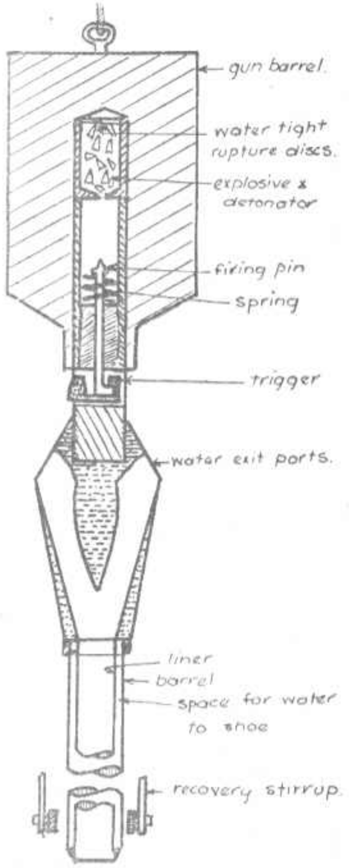


Fig. 2.

A diagram of the sampler is shown in figure II. It consists essentially of five parts :

(i) The gun—a heavy weight ;
(ii) The cartridge and firing mechanism ;
(iii) A coupling with streamlined vents to let out water ;
(iv) The sampling tube, and
(v) A stirrup for extracting the tube and hauling to the surface.

The cable for lowering is connected to the gun and then again to the stirrup. The cable to the stirrup is slack and the sampler is lowered, and it can be adjusted to various lengths for various penetrations. The weight of all parts below the gun is carried by two small shear pins, so that when the bottom is reached the gun slides down over the trigger and the gun is fired. The recoil is taken by the gun and the hydrastatic pressure.

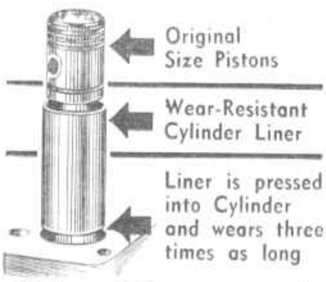
The water exit ports have no valves, are streamlined and practically straight, and have a cross-sectioned area equal to that of the sampling tube. The barrel has liners inside, so that the sample can be removed from the barrel and transported without trouble. The barrel has four lands cut so that four spaces are formed between the liner and barrel. These pass water to below the sampler to relieve the vacuum formed at the shoe as the barrel is pulled out. Without this precaution the sample is liable to be pulled out or damaged, or else the tube is firmly held and cannot be pulled out at all.

This particular model, the "Piggot Gun," has been used successfully to 20,000 ft. below sea level. It obviously is the only good method for exploring the sea floor, but this is coming into prominence for land work as well. The high speed of penetration avoids buckling of the barrel, and decomposed rock stratum have been taken with only slight injury to the barrel and cutting edge. The only connection to the surface is a single cable. When this method is developed it may well become a serious rival to all other methods now employed.

Soil Compaction.

A method of compacting loose cohesionless foundation soils in their natural state by exploding buried charges of dynamite has been employed very successfully on several American dams. The soil must be at or near complete saturation, and this being complied with, the method is applicable to all loose cohesionless structural foundations. The investigations so far show that horizontal permeability in stratified deposits is greatly reduced, and this, of course, is of vital importance in dam construction.

Such foundations as mentioned are unstable and may easily fail by "liquifaction" and consequent flow under load, when any vibration occurs in the neighbourhood—earth tremors, blasting, demolition, etc.



Original Size Pistons
Wear-Resistant Cylinder Liner
Liner is pressed into Cylinder and wears three times as long

The method was originally developed for sands, but has now been extended to silts as well. Saturation of the soil pores causes the shocks to be translated in the pore-water to greatest effect, but good results have now been obtained when the soil is only partially saturated. The explosion causes what is called "liquifaction" of the soil mass followed by escape to ground surface of the excess pore-water as the soil grains re-arrange themselves to a different pattern. The escaping water helps this action by reducing friction. The effect is most pronounced in the immediate vicinity, and particularly on top of the charge. Undisturbed sampling, which has to be carried out as a control, has not disclosed any cavities. These may have been formed momentarily as the charge exploded.

Strata at considerable depth may be compacted simply by this method; the cost of pile driving and mechanical vibrators, which have been used in the past, becomes prohibitive in this case.

The size and distribution of charges should be such that they will shatter the soil, but not cause permanent surface cavities. Any impervious crust must be loosened or removed so that the excess water may escape. Following the low thud of the detonator there is an upheaval of the soil and gas and water may escape for minutes or hours. The primary surface settlement takes place immediately after the first upheaval and a continual settlement continues for a few minutes. Calculations on the final and initial ~~paid~~ pore ratios show that the amount of water yielded is much greater than could have been caused by the change in paid ratio alone, so that lenses must have become broken up.

Up to 30 ft. depth one tier of charges is suggested at two-thirds of the depth of the stratum. At depths greater than 30 ft. two tiers are best. At Franklin Falls Dam there was a layer of 30 ft.—15 ft. of loose saturated sand and it was found that the optimum charge was 8 lb. of dynamite at 15 ft. depth at the corners of a 10 ft. grid. After firing there was a settlement of 1.25 ft. and an average compaction of 36%. Successive blasts on the same ground produced further settlement. In each case the best values must be arrived at by test.

Conclusions.

These methods have only been used over the last few years, and so as yet have not been developed to their full extent. They have great possibilities, and we will probably hear more of them soon. One trouble with these methods has been the prohibition on the use of explosives in settled areas, but actually the charges for pile driving and soil sampling are not very great and are only of slow burning powder, so they are probably not very offensive. Nevertheless, this seems to be a definite limiting factor on their universal development. However, this does not apply in more remote locations and most of civil engineering jobs seem to be done in remote locations any way!

Steam Turbine Trouble-Shooting

By R. D. WHITE and
G. A. TOLHURST

Turbine design looks easy—simply follow the standard methods given in lectures and textbooks, and calculate a few blade rings, discs, and so forth. Then, if you're lucky, she'll get you a pass in Design! Installed in a powerhouse she'll get someone a pass to heaven in double-quick time. This article explains why, and what can be done about it.

1.—**TURBINE operation** has scored a remarkably low accident rate, despite the rapid development of this type of power plant for both land and marine work, and the wide adoption of high-speed non-stop units for large outputs. However, engineers, being but human, it's only to be expected that some accidents, serious enough from the technical viewpoint, but not grisly enough to reach the papers, occur without the engineering world being any the wiser. While not many of us are over-anxious to chalk up our failures for the world to see, nevertheless full authoritative investigation of turbine failures would have impressed on designers and operators the importance of understanding the conditions under which the various parts of a turbine must operate.

Besides combating this hush-hush tendency, the would-be trouble-shooter has to solve the problem, "What part went first and where is it?" Not only is the wreckage often gloriously complete, making it a tough job to spot the offending part, but also some brilliant detective work is required to ascertain all the accompanying circumstances. Thus, to discover the true cause of a failure, and to avoid vibration of the particles is the same for each. The type of vibration responsible for most wheel failures consists of a backward-travelling wave, whose backward speed in the wheel exactly equals the forward speed of rotation, resulting in waves which are stationary in space—and if, at particular wheel speeds, these are resonant with the natural "standing vibration" of the disc, the wave train develops great amplitude and the disc may fail. Since the frequency of the "standing vibration" differs according to the number of nodes, there will be several critical speeds at which resonance occurs.

Thus it only takes a few pounds variation (due maybe to partial admission or slight differences in nozzle and blade pitch or angles) in transverse steam force to persuade a wheel running at any of these critical speeds to indulge in violent physical jerks. Unless you're a superman you can't possibly predict or prevent these small differences, and the only thing to do is to see to it that all the wheels in the rotor without exception are designed **and** manufactured **and** tuned so that all, when fully bladed, are free from any critical speeds within at least + 15% of the operating speed. If the safety margin isn't generous enough, sudden load changes, with consequent rapid temperature changes at the rims, may cause failure by temporarily altering the critical frequency.

Examples: (a) The 11th and 17th stage diaphragms of a 30,000 k.w., 1,800 r.p.m., 17-stage turbine were found to be badly scored just outside the nozzle rings by vibrating wheels, which were promptly replaced. (b) A vibration fatigue fracture in the 11th stage of a 30,000 kw., 1,500 r.p.m., 12-stage unit did not pass through steam balance holes; but (c) in the 3rd stage wheel of a 6,000 h.p. marine job, the failure sketched in Fig. 3 started at two such holes. The fracture is typical and "wherefores" of common turbine troubles is vital, and the following remarks and examples may prove helpful.

Figs. 1 and 2.

2.—**Vibration** (shaft, disc, or blade) is foremost on the danger list, since high peripheral speeds and close tolerances are the rule. Shaft vibration, which is fairly easily spotted, may result from resonance at a critical (vibrating) speed, which also happens to be the operating speed—in which case the designer or the operator, or both, should be shot, as this is exceedingly poor. Otherwise, faulty balancing or a badly aligned shaft is possibly to blame; sometimes a momentary overspeed or other temporary cause of whirling may bend the shaft very slightly, resulting in destructive vibrations later on in its life.

Example: In one failure, where whirling of the shaft completely smashed up the blading of a marine turbine, faulty lubrication of a main bearing had led to excessive wear, the load then coming upon an adjacent bearing; this increased the effective length of the shaft, and the critical speed fell to within the operating range, with the usual dire result (see para. 3).

3.—**Disc Vibrations** are rather complicated, but, fortunately, nearly all investigated fatigue failures have been due to one particular kind of vibration, which gives several critical speeds for each disc of the rotor, thus:

The vibrations of the discs not only occur in segments with stationary, radial nodes, as would be expected of an elastic plate (see Fig. 1), but also as a wave train travelling around the wheel circumference, as in Fig. 2. These two forms are known respectively as "standing vibrations" and "travelling waves," and the natural frequency of

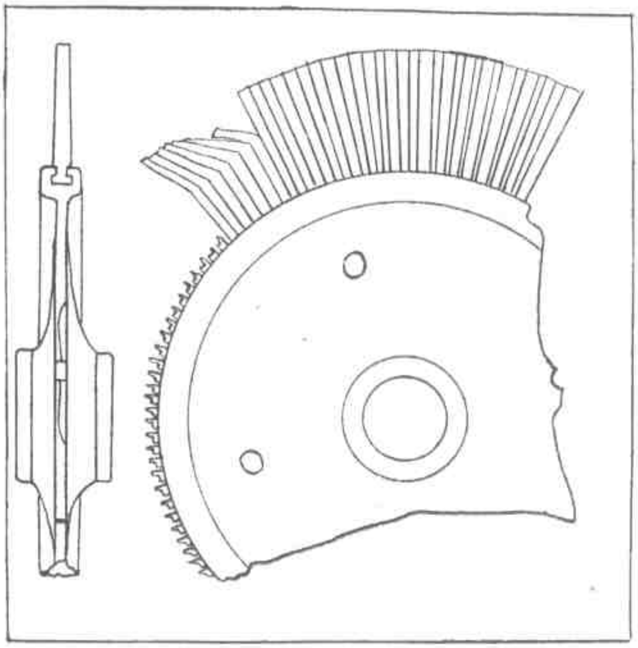


Fig. 3.

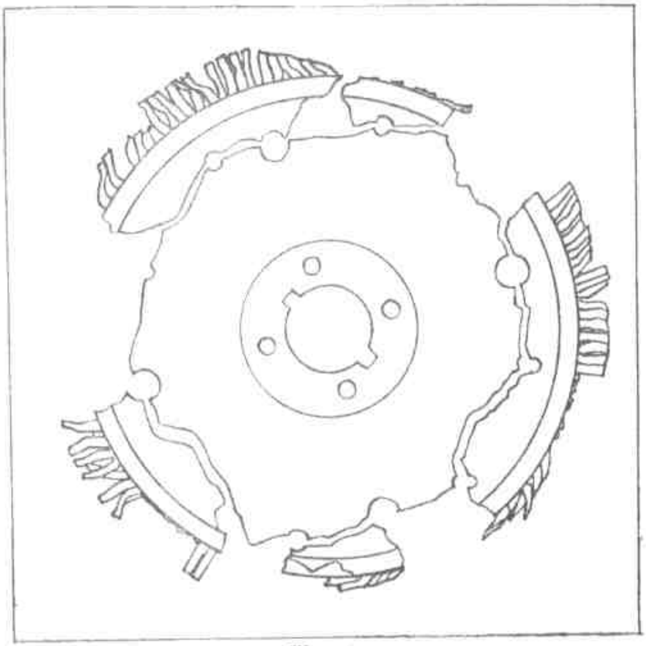


Fig. 4.

of fatigue failures and is easily distinguished from that of Fig. 4, which shows "bursting" due to overspeeding. Owing to fog, the ship had been steaming with a screw speed of 84 r.p.m., corresponding to 48 r.p.s. of the turbine, which turned out to be the 6-node critical speed of the 3rd stage disc.

The latest Brown-Boveri turbines have all the discs welded together around their periphery to form an extremely strong drum, with no central shaft inside it; this eliminates many vibration difficulties.

4.—**Blade Vibrations.** Since wheel and buckets vibrate together as a continuous disc they have been treated as one unit in para. 3; however, you usually have the dark mysteries of thermodynamics dictating most of your blade dimensions, and even after designing the completely bladed wheel as a safe unit, you may find that the natural frequency of buckets you thus choose is alarmingly close to the frequency of certain disturbing forces peculiar to the blade ring—e.g., lateral vibrations due to travelling waves at the wheel circumference, steam impulses, or "standing" disc vibrations. This means you will have to treat the blades as independently vibrating parts and check the stiffness against these possibilities of destructive resonance. Erosion raises another blade design headache which is treated in para. 6.

Examples: (a) The breaking of bucket dovetails in the last stage of a 30,000 kw., 1,800 r.p.m., 17-stage turbine was found to be due to a backward travelling waves, the fractures showing that lateral motion of the buckets had been occurring for a considerable period before rupture. (b) A 45,000 k.w. turbine, with blades 34 in. long in the 21st and last stages, was put out of service and 100 of the condenser tubes slashed when vibration fatigue caused failure at the blade roots. It is here, or at the tangs of the dovetails, that the greatest stress concentration occurs when vibration stresses due to poor design are superimposed upon the centrifugal stresses, causing minute fatigue cracks which form a starting point for complete fracture.

5.—**Defects in Materials and Workmanship.** It's a bit tough when you've designed the Perfect Turbine, seen a few installed and running beautifully—and, without warning, one of them goes sky-high because of a hidden flaw in the material. This danger can be minimised by specifying rigidly the materials tests, inspection requirements, and manufacturing technique; for instance, rotors of the solid-forged type should be examined by means of exploring devices in an internal bore specially provided to spot central "pipe" cavities; or, better still, by latest X-ray technique.

Example: A 20,000 k.w. reaction turbine was completely wrecked and several engineers killed at Shanghai when the turbine shaft suddenly failed in a terrific explosion that filled the station with flying fragments and live steam. Rupture occurred at normal operating speed, without any warning (such as excessive vibration) and the calculated rotor stresses were not high, so it appeared that a hidden defect in the forging was the cause of the calamity.

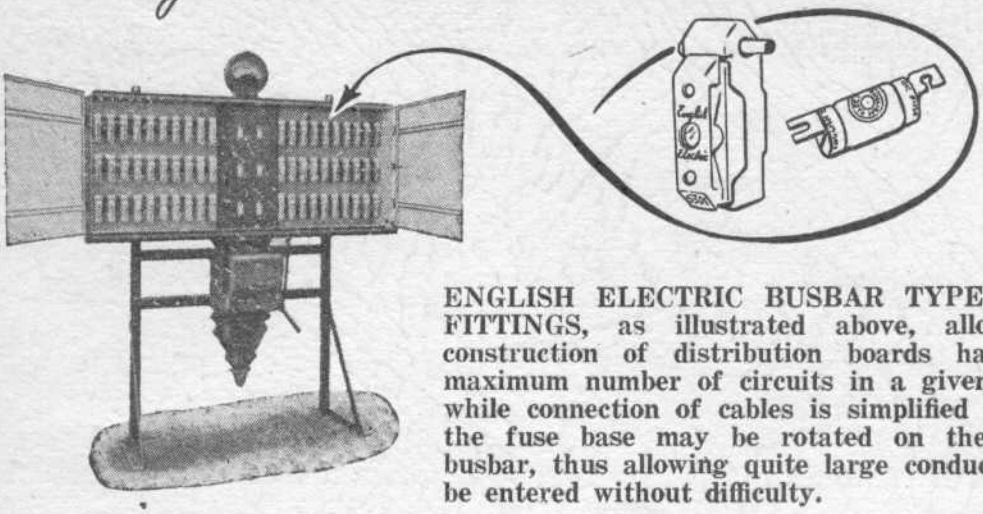
The wise designer, who knows what tolerances to specify where, can usually anticipate where faulty workmanship is likely to have serious effects, and tighten up on his specifications and production control to minimise this danger. Disc machining must be highly accurate, with very smooth finish and perfect static and dynamic balance, supplemented by "tuning," as in para. 2. Balance holes must have smooth, rounded edges, or fatigue failure may get an early start (Fig. 3) . . . and so on—but we'll leave the production side and consider:

6.—**Blade Erosion.** At the exhaust end of a large condensing turbine a tremendous volume of wet steam is handled by the last few blade rings, which, therefore, must be very long and get around in quite a hurry—say, 1,200 ft. per second—in the latest jobs. The myriad tiny condensed water droplets in suspension are unable to keep up with the rush and blast at the backs of the blades, causing rapid wear and consequent vibration, if the blade material can't take it.

Fortunately, the much maligned metallurgist has of late taken up the problem of blading materials with commendable zeal, especially in connection with the I.C. gas turbine with its ultra-high temperatures and velocities, so that if you keep up with the design rags (particularly the ads.) and metal trade publications, you won't be at a loss for suitable heat-and-wear resistant materials in the post-war era; it will be a matter of choosing the most economical one to do the job in your particular brain-child.

REFERENCES: "Machine Design" (Feb., March, May, 1945), "Brown Boveri Review," "Metal Progress," "Steam Turbine Operation" (Kearton), "Protection of Steam Turbine Disc Wheels" (Campbell).

English Electric Distribution Boards!



ENGLISH ELECTRIC BUSBAR TYPE FUSE FITTINGS, as illustrated above, allow the construction of distribution boards having a maximum number of circuits in a given space, while connection of cables is simplified because the fuse base may be rotated on the round busbar, thus allowing quite large conductors to be entered without difficulty.

★

ENGLISH ELECTRIC BUSBAR TYPE FUSE FITTINGS are made in 30 ampere, 60 ampere, and 100 ampere sizes and are provided with front indication. They are designed for use with English Electric High Rupturing Capacity Non-Deteriorating Cartridge Fuses.

NOTE REDUCED PRICES	30 amp. Handle and Base, Type S30B	6/1 each
	60 amp. Handle and Base, Type S60B	6/7 each
	100 amp. Handle and Base, Type S100B	18/1 each

We build switchboards to meet your requirements or will supply designs on request.

THE ENGLISH ELECTRIC CO. LTD.

(INCORPORATED IN ENGLAND)

AUSTRALIAN OFFICES:
SIEMENS (AUSTRALIA) PROPRIETARY LTD.
SYDNEY · MELBOURNE · ADELAIDE · BRISBANE · NEWCASTLE

FLOWER DAVIES & JOHNSON - PERTH
H. M. BAMFORD - - - - HOBART

E. J. McAlister & Co.,
Printers
24 Blyth Street,
Adelaide.